ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 61. No. 23. 220 Broadway, New York, June 10, 1909.

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Turning the Colorado River and Completing the Laguna Dam, Arizona-California.

By EDWIN D. VINCENT.*

When the U. S. Reclamation Service assumed control of the construction of the Laguna Dam, Jan. 23, 1907, to be carried forward and finished under the force-account system, the big problem presenting itself, and which meant the success or failure of the enterprise, was the closing of the Colorado River.

A detailed description of the river and dam was given in the Engineering News of Feb. 27, 1908. Since that date, one radical change has occurred in our plans: the sluiceways have been transposed and the main canal away from the dam is now from the California heading.

The flow of the river ranges from about 6,000 sec.-ft. during the fall to 118,000 sec.-ft. at the height of the summer flood, which peaks usually in June. Therefore the turning of the river and the closing of the gap across the channel had to be accomplished during the fall and the early winter months, and all efforts were bent toward this end in the fall and winter of 1909, when it was reasonable to suppose that not over 20,000 sec.-ft. would have to be opposed up to the middle of March.

The cut-bank channel of the river at the dam site was originally 1,100 ft., and at first it was thought that width would have to be left open until the final closing, but at the height of the summer flood of two years ago, when the stream was carrying 118,000 sec.-ft., it was noticed that while the California side was being savagely attacked, the river was throwing up a center bar in the 1,100-ft. channel and at the same time there was no disturbance on the Arizona side. Upon the strength of this demonstration that the waterway left was wider than necessary, immediately after the flood subsided the work on the Arizona side was pushed out into the river until the gap between banks was reduced to 625 ft. and the two ends thoroughly protected by rock cofferdams. With the restricted channel thus protected, the work passed through the flood season of 1908 without damage.

From the time the Reclamation Service took over the work, the principal efforts were directed toward completing the two sluiceways to serve as avenues for the water during and after the final closure. The bottom width of the Arizona sluiceway is 42 ft.; that of the California sluiceway, 116 ft. (See general plan, Fig. 1.) Both are excavated in the native rock and lined and paved with concrete. The two combined were calculated to carry 20,000 sec.-ft. before the crest of the dam (Elev. 151.0) would be topped. The bottoms of the sluiceways are at Elev. 138.0, while the ordinary stage of the river is 141.0.

Throughout the summer of 1908 about 600 men were engaged on the work, divided into two shifts of eight hours each. To enable the workmen to bear up under the intense heat while working under pressure, the work was so divided that the first shift came on at 4.30 a. m. and worked until 1 o'clock, when relieved by the second, which continued on until 9.30 p. m. By this method no man was exposed to the fierce heat of the sun

*Resident Engineer, U. S. Reclamation Service, Yuma, Ariz.

READY TO BEGIN DUMPING ROCK TO CLOSE THE LAGUNA DAM ACROSS THE COLORADO RIVER, NEAR YUMA, ARIZ.

(View taken Dec. 10, 1908, from above the California sluiceway, which is shown in foreground. The two trestles crossing the river formed the core of the upper and lower cofferdams. Rock was dumped from the trestles. The dikes above have been cut, and the water is just coming through the sluiceways.)

throughout the entire day, and it was possible to carry forward the work expeditiously.

With the subsidence of last summer's flood, work was commenced in the river section of the dam preparatory to its closing. The method adopted was, with some modifications, the one which had been successfully used by the Southern Pacific Co. on the Colorado River below Yuma in closing the break to the Salton Sea; that is, standard railroad trestles were used to form the upper and lower sides of the cofferdam, from which rock was to be dumped until the stream would be choked and the fill finally made watertight by the silt deposit. An additional feature intended for this work, but later abandoned on the strength of the Southern Pacific Co.'s accomplishment, was a woven willow mattress about the foot of the piles, as used by the U. S. Corps of Engineers along the Missouri River on work of similar nature, but from our recent experience I believe it would have been economy to have added the brush mattress feature, as originally intended.

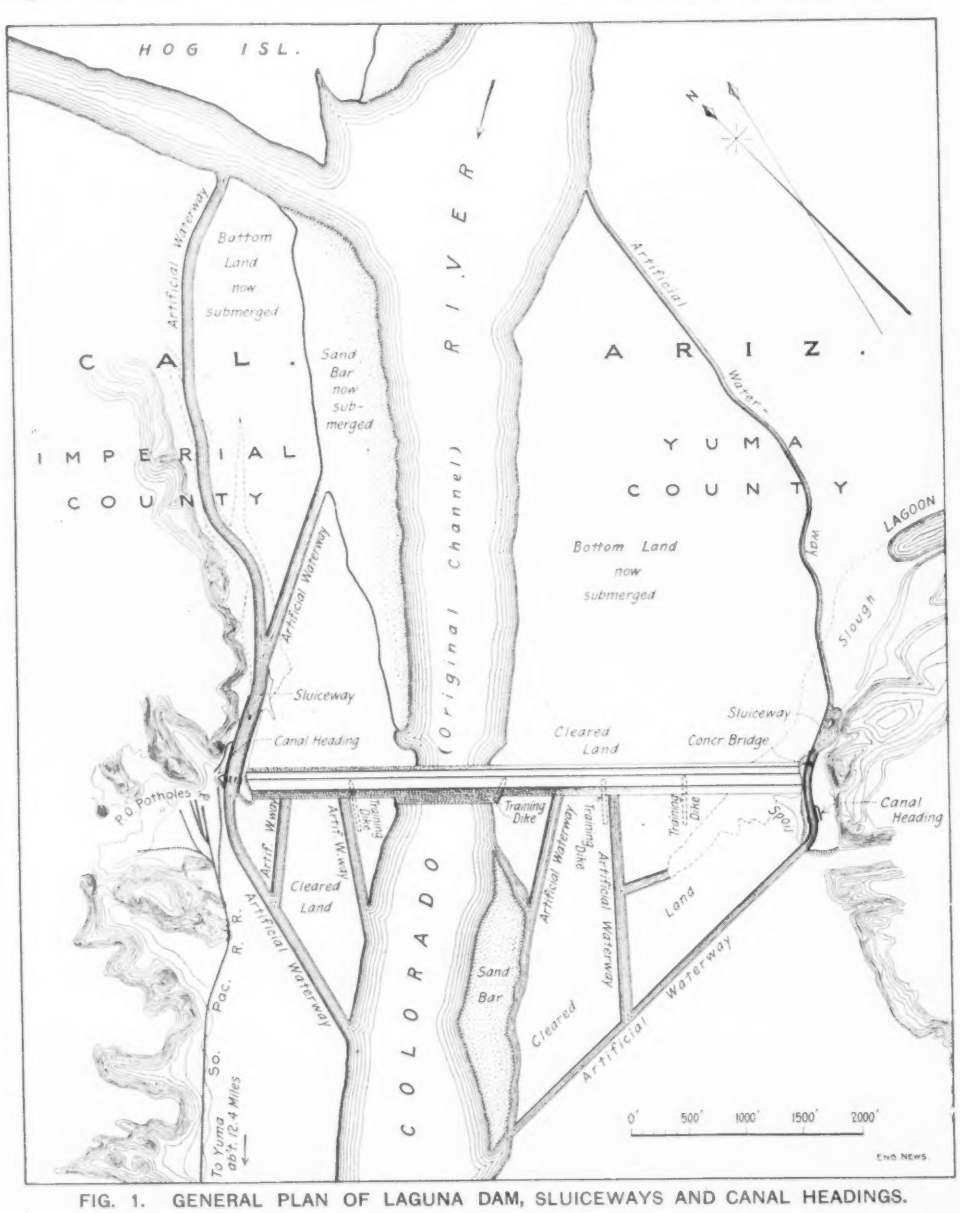

FIG. 1. GENERAL PLAN OF LAGUNA DAM, SLUICEWAYS AND CANAL HEADINGS.

The upper trestle, 740 ft. long, was located 152 ft. up-stream from the crest wall of the dam, with base of rail at Elev. 156.8. The lower trestle, 728 ft. in length, was located 90 ft. from the lower toe wall, or 40 ft. beyond the toe of the apron, with base of rail at Elev. 149.8. (See Figs. 1 and 2; also the front-page engraving.) Piles were driven to a penetration of 21 ft. and over. Pile-driving was commenced in October and the two bridges were completed in November, 1908. Immediately following the completion of a bridge, the dumping of spoil and waste from the quarries into the deeper parts of the channel commenced; this in order to cut out the center bar and to bring the bed of the river to a uniform depth. By this means, when it came to the final work, the entire channel under the two bridges had been blanketed with probably 6 ft. of spoil and a fairly even depth of 4-ft. water secured entirely across the opening. In the meantime a large force of teams had been transferred from the levee camps below and set to work digging channels from the river above to the two sluiceways and out again below, with bottom widths of 30 ft. and 80 ft.

These channels could only be taken down to about Elev. 141.0 on account of the ground water, so the river was depended upon, after a head was established, to cut to a depth required to pass all the water to and away from the sluiceways.

During the summer months the crews on the Arizona side, having less work to accomplish, were employed part of the time in selecting derrick-sized rock from the quarries and storing it out on the dam to be available for emergency purposes when the final closing should be attempted.

By Dec. 10 the sluiceways and artificial channels were completed and a head of 2.8 ft. had been established by the cofferdams. The dikes at the headings were then cut and dumping into the river with the run from both quarries began in earnest. The lower cofferdam was first given attention until the head obtained was 3.5 ft., then all efforts were concentrated on the upper cofferdam and the head on the lower simply maintained.

The equipment prepared for this work consisted of one 2½-yd. Atlantic shovel and one 2½-yd. Model 60 Marion shovel, both located in the California quarries; six 18-ton standard gage Davenport industrial locomotives, 50 6-yd. Kilbourn & Jacobs dump cars, 18 5-yd. Koppel steel dump cars, 50 industrial flat cars and seven 12-in. American Hoist & Derrick Co. steam hoists. The hoists were located in the Arizona quarries and at the emergency storage rock pile out on the dam.

Bridges had been constructed over both sluiceways and a double-track system was established from the quarries to the cofferdam. The haul ran from 1,500 to 3,500 ft. About 600 men were worked in two shifts of ten hours each, the eight-hour law having been set aside temporarily by a declaration of the emergency condition existing at this time.

The work at night was carried forward under an electric lighting system, and telephone stations were established at all critical points.

On Dec. 12 the head on the dam was raised to 4.4 ft., with a flow in the river of 8,950 ft., 900 sec.-ft. of this passing through the sluiceways. On Dec. 13 an incipient break occurred through the lower cofferdam, but by the next day this was closed. On the 14th the discharge of the river was 7,725 sec.-ft., with 1,700 sec.-ft. passing through the sluiceways and a head established on the dam of 5 ft. On the 16th the discharge of the river was 7,475 sec.-ft., the head established was 6.9 ft. and the flow through the sluiceways 2,700 sec.-ft. On the 17th a more serious break (Fig. 3) occurred about midway in the upper cofferdam, with a head above the middle pool of 5.3 ft. Although the flow in the river had increased to

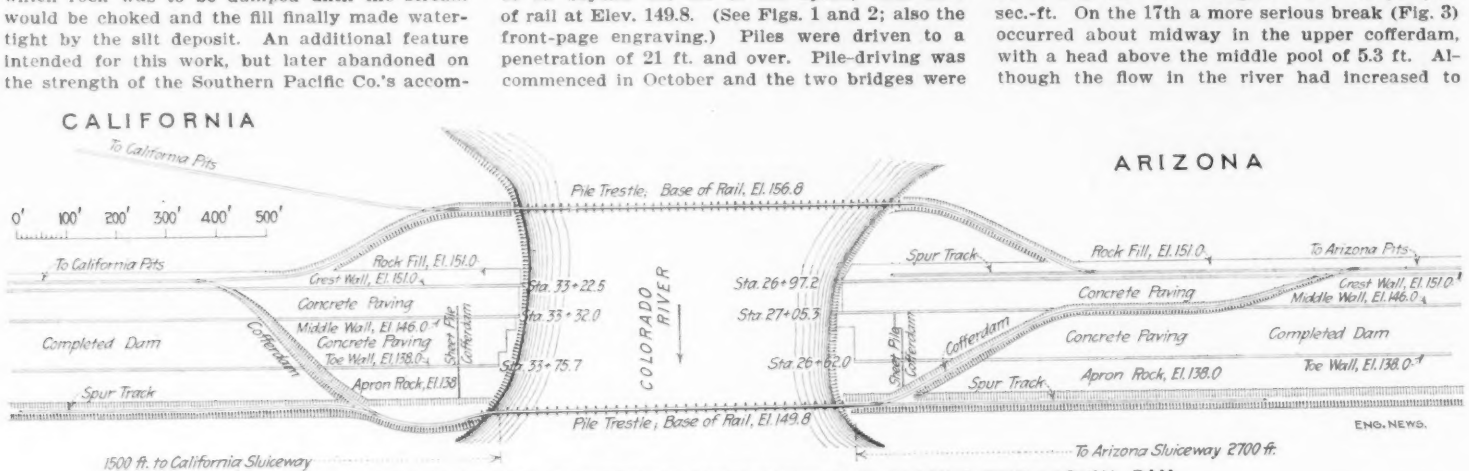

FIG. 2. ARRANGEMENT OF TRESTLE AND TRACKS FOR CLOSING THE LAGUNA DAM.

000 sec.-ft., the flow through the sluiceways opped to 1,400 sec.-ft. By the next morning, ough dumping into the break had continued rough the night, the break had widened to 150 with a depth of probably 20 ft. and with the w so strong that it had extended on across the

FIG. 3. BREAK IN THE UPPER COFFERDAM OF THE LAGUNA DAM, DEC. 17, 1908.

middle pool and breached the lower cofferdam as well. Both trestles held, however, and by turning to the emergency pile of derrick-sized rock stored on the adjacent bank, the cutting was stopped; then by using the output of rock from every available source the holes through the cofferdams were gradually choked and by the night of the 19th the former head above the dam had been nearly restored, although the water was still pouring through the gap. On this date the flow in the river was 11,680 sec.-ft., and the amount passing through the sluiceways was 3,150 sec.-ft.

A heavy wind and rain storm swept over the entire southwest country on the 14th and 15th, and on Dec. 16 a wire from Holbrook, Ariz., announced the coming of a big flood down the Little Colorado, 600 miles by river above Laguna Dam. The closing of the river was now concentrated on the upper cofferdam, where the flow had been restricted to the 150-ft. opening, the lower cofferdam having been abandoned for the time being. With the steady stream of rock that was being poured into the break, the effect soon became apparent, for the larger rock began to show up in the opening, and by noon of the 21st the gap had been closed and the Colorado River turned, the entire flow of 9,950 sec.-ft. passing through the sluiceways, with a head of 8.9 ft. established above the dam.

All efforts were now centered on the work of raising the upper cofferdam above the danger line of the approaching flood. By morning of the 22d the advance of the flood had reached Laguna Dam. The water rose steadily all day, and by noon the sluiceways were taxed to their utmost capacity (about 18,000 sec.-ft.) and the water began creeping over the crest wall of the finished portion of the dam on either side of the cofferdam. (See Fig. 4; also see Figs. 5 and 6 for views of California sluiceway.)

By four o'clock the rising waters had so covered the railroad tracks as to cut the communication between the Arizona quarries and the river cofferdam, and at seven o'clock the river section of the dam was entirely isolated by the rising water cutting the California connection. Fortunately one train of empties was marooned out on the California side of the dam, and this was run to a storage pile of broken stone and sand which had been accumulated for future concrete work. This supply was drawn from until midnight, when the fires under the engine were extinguished by the still rising water. In the meantime about 60 men had been put out on the cofferdam, who, with sand sacks loaded from an old dredge deposit within the enclosure, were helping to build up the low places. With all other sources of supply now cut off, this sort of defensive work continued throughout the night. The flood crested at 5 a. m., with the cofferdam still holding and its general level about 10 ins. above the highest point reached by the water, the gage reading 153.2 and the head of the water being 10.1 ft.

In the meantime the water passing over the finished portion of the dam on either side of the river section, finding no suitable outlet beyond the apron, which is about seven feet below the general level of the ground, turned lengthwise of the dam and rushed to the opening through the lower cofferdam, carrying away the two end cofferdams, wrecking the railroad tracks across its course and sinking the suction dredge which lay moored in the pool between the two cofferdams.

During the height of the flood the levee below the mouth of the Arizona sluiceway broke, driving out the grading camp and flooding the country below.

On the California side the current attacked the land front below the sluiceway, threatening to carry away the Government store, mess and supply-house buildings, but the communication out to the dam having been cut off, the steam shovels and equipment were turned to the protection of the cutting banks. By strenuous work the bank cutting was stopped and the buildings saved.

At 6 a. m. of the 23d, it being clear that the rise had crested and was subsiding, the crew that had been working through the night at raising the cofferdam was withdrawn, and replaced by watchmen to guard against any weak spots that might develop. The flood, however, subsided rapidly, and no further damage was sustained. Advices the next morning from the Yuma gaging station were to the effect that the upper cofferdam had been successfully held against a flood of 35,250 sec.-ft.

Immediately after the flood, the work of restoring railroad tracks, picking up wreckage, rebuilding the lower cofferdam and raising the crest of the upper one above the danger line was begun.

Table I. gives quantities and cost of turning the Colorado River at Laguna Dam and making the cofferdam secure for the completion of the dam. Table II. shows Yuma gaging station records of the volume of discharge of the river during the three times it has been turned from its course.

By Jan. 6, 1909, the track system had been restored, the cofferdam reconstructed and raised above the danger line and the work of filling in the 650-ft. gap and the completing of the dam commenced. Two 15-in. and three 10-in. centrifugal pumps, belted to 35-HP. and 40-HP. distillate engines and capable of handling 25,000 gals. per min., were installed in the sump to keep down the seepage. The force employed was between 500 and 600 men, working in two shifts of eight hours each. The equipment used was the same as that in closing the river, with the

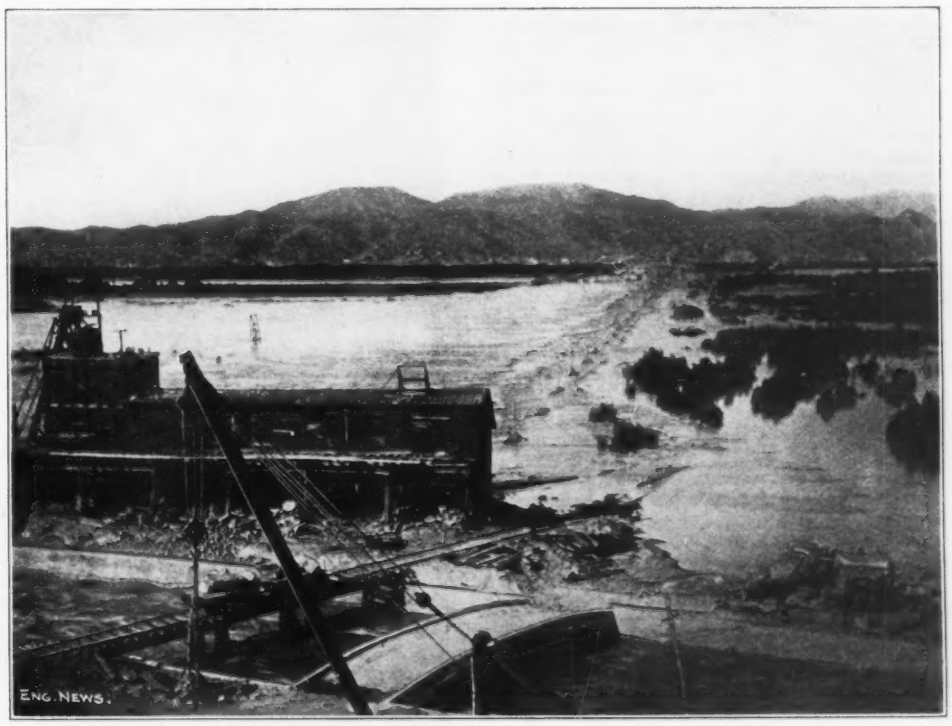

FIG. 4. FLOOD WATER PASSING OVER FINISHED PORTION OF LAGUNA DAM, BETWEEN THE ARIZONA ABUTMENT AND THE RIVER COFFERDAM, DEC. 23, 1908.—ARIZONA SLUICEWAY IN FOREGROUND.

TABLE I.—COST OF CONSTRUCTING COFFERDAM FOR TURNING COLORADO RIVER, LAGUNA DAM.

	Oct.	Nov.	Dec.	Jan.	Total.	Per-centage.
Labor—dumping cars	....	....	$1,478	$214	$1,692	1.96
Labor—general	$400	....	962	277	1,639	1.90
Sundry supplies and implements	....	....	463	196	659	.77
Railroad hauling	1,159	1,732	13,157	1,899	17,946	20.85
Depreciation, rolling stock and track	290	517	3,710	651	5,168	6.00
Excavation, Class 1*	....	9,636	24,326	4,755	38,717	44.98
Trestle bridges†	7,411	4,940	....	24	12,375	14.38
Proportion, storage of apron rock	....	....	1,168	....	1,168	1.36
Light and water	....	65	475	364	905	1.05
Depreciation on special derricks	....	....	49	....	49	.06
Proportion of superintendence	187	149	2,098	200	2,633	3.06
Overhead charges‡	299	198	2,355	268	3,121	3.63
Totals§	$9,745	$17,236	$50,242	$8,849	$86,072	100.00

*Solid rock excavation, 59,790 cu. yds.; on putting this into the dam loose, it made 82,794 cu. yds. of fill.
†The two trestles that formed the cores of the upper and lower cofferdams; total length, 1,468 ft.
‡Proportionate charges from the Yuma and Washington offices.
[§Discrepancies in totals due to our dropping cents and substituting nearest dollar. The totals we give are the correct totals, to the nearest dollar.—Ed.]

exception of one steam shovel and two steam derricks.

The new cross-sectioning of the gap developed such radical changes in the bottom that former methods used in carrying the dam forward were abandoned and new ones adopted to complete the work before the spring floods. Heretofore the earth excavated had been removed by the suction dredge and the rock fill in the dam carried forward by traveling derricks, with the sheet piling and core walls slightly in advance. The conditions found on resumption of construction work were as follows: The suction dredge had been sunk and lay in 15 ft. of water. However, the rush of water doing this damage had also worked a benefit, for instead of some 40,000 cu. yds. of earth we had expected to remove, the quantity found was less than 8,000 cu. yds. But the scouring action of the water did not stop at grade, for we also found that instead of 35,000 cu. yds. of loose rock, sufficient to complete the dam, it would now require something over 80,000 cu. yds., as the scour had extended in places to 30 ft. below the proposed base of the dam.

First, two additional bridges were built across the gap, one immediately below the line of the middle wall and the other immediately above the crest wall. The piling for these, as well as the sheet piling under the crest wall, was driven by a steam pile-driver from off a raft. By dumping the run of the quarries from these bridges, the base of the dam proper was restored and the rock-fill itself extended both up-stream and down-stream by building and throwing track. The core walls were also constructed by dumping the concrete from the cars directly into the forms. The paving, too, was laid by dumping directly into the forms, in strips about 16 ft. wide, extending the length of the opening, the construction track being thrown to the lower edge of each finished strip in order to construct the next one below. At one time there were six lines of track across this portion of the dam that was under construction.

A large force of teams was employed during January and February in digging channels away from the apron in order to avoid dangerous parallel currents along the toe of the dam, when flooded. Fig. 7 is a view of a portion of the completed structure, as it appeared on March 14, 1909.

One rise of the river in January topped the crest wall of the dam by 6 ins., but having had due notice of its coming, the work was protected from flooding by building a low dike the entire length of the crest wall, and the only inconvenience suffered was the over-taxing of the pumps for a few days.

The construction work was completed and the pumps taken out on March 27. Four days later, on March 31, 1909, the dam was topped by a flood, the discharge of the river being 40,800 sec.-ft.

During the eighty days that intervened between Jan. 6, 1909, when the work of closing the gap in the river section began, to March 27, when the dam was completed, there was quarried 63,896 cu. yds. of rock; 81,839 cu. yds. of loose rock were placed in the dam; 7,754 cu. yds. of sand and earth were removed, mostly by sluicing to the mud pumps; 10,231 lin. ft. of 6 × 12-in. sheet-piling were driven and 9,359 cu. yds. of concrete placed in the walls and paving.

These features of the work were not all carried forward simultaneously, some having had to wait until others were well on their way to completion.

During the month of March a considerable portion of the force was engaged in dismantling machinery, tearing up tracks, etc., and removing them off the face of the dam as fast as they were relieved from duty. This work was continued until the dam was overtopped by the flood of March 31. Everything had been removed, with the exception of one mile of main line track located along the crest wall of the dam. We do not consider this lost, however, as we hope to recover it when the present flood shall have passed.

TABLE II.—DISCHARGE OF THE COLORADO RIVER IN SECOND-FEET DURING THE PERIODS IN WHICH IT WAS TURNED FROM ITS COURSE.

So. Pacific Co.'s first closure in Mexico, 1906.		So. Pacific Co.'s second closure in Mexico, 1907.		Reclamation Service closure at Laguna Dam, 1908.	
Oct. 26	9,200	Jan. 27	13,800	Dec. 11	9,050
27	9,000	28	13,200	12	8,950
28	8,800	29	12,700	13	8,125
29	8,600	30	12,700	14	7,725
30	8,600	31	12,700	15	8,300
31	8,600	Feb. 1	12,400	16	7,475
Nov. 1	8,600	2	25,700	17	10,000
2	9,200	3	31,300	18	12,700
3	9,200	4	26,600	19	11,682
4	9,100	5	24,400	20	8,952
5	8,800	6	19,200	21	9,950
6	8,500	7	17,700	22	16,525
		8	19,000	23	35,250
		9	20,500		
		10	20,800		
		11	20,300		
		12	18,900		
		13	17,400		

Continuous Melting in Foundry Work.*

(1) By S. D. SLEETH.†

When the Westinghouse Air Brake Co. found it necessary to enlarge its plant, on account of increased business, it was decided to move to Wilmerding, Pa., and install, in the foundry, flask and sand conveyors. This meant that the foundry would have to run so that iron could be poured all day, instead of two or three hours in the afternoon. We knew of no plant where this was being done, so it was up to our foundry to work it out. As it required about 2½ hours to run the heat off at that time, we decided to see how much longer we could hold the metal in the cupola and still keep it hot. The first day we put the blast on half an hour earlier and melted

*Abstracts of two papers presented at the annual meeting of the American Foundrymen's Association, at Cincinnati, Ohio, May 18 to 20, 1909.
†Westinghouse Air Brake Co., Wilmerding, Pa.

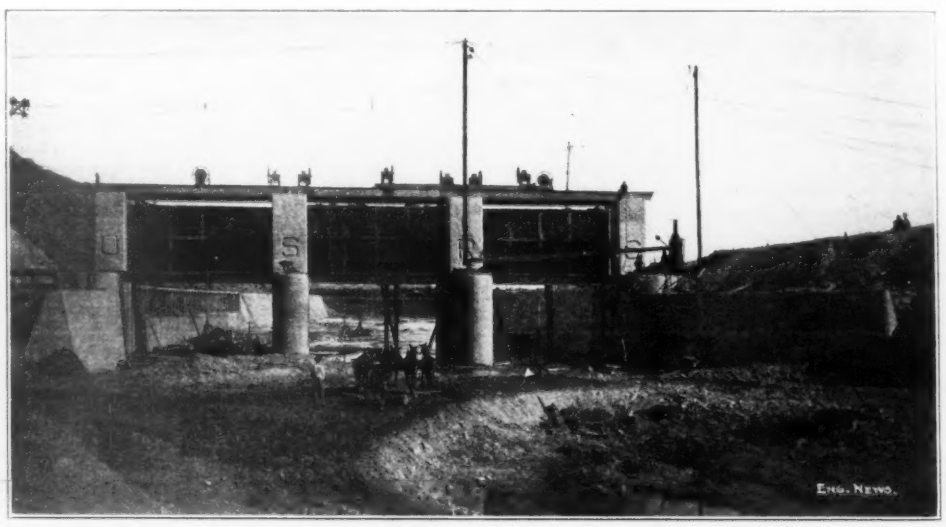

Fig. 5. About Ready for Use, Dec. 1, 1903.

Fig. 6. In Use to Full Capacity, Dec. 23, 1908.

FIGS. 5 AND 6. THE CALIFORNIA SLUICEWAY OF THE LAGUNA DAM, FROM BELOW.

iron with the same blast pressure, but would shut blast off for five or ten minutes and then start to w again. This we found to work satisfactorily for day. The second day we put the blast on one hour er, but this did not work so well. We therefore ed more coke, which kept the metal hot, but the melt- was slower.

hen we started work in the new foundry at Wilmer- g, we ran two cupolas, one in the morning and one in fternoon. We were afraid to hold over dinner hour. r running for some time in this way, we decided to one cupola all day. At about 11 a. m. we added 200 of coke for two or three charges so that we would e an extra amount of coke to hold over the dinner our. Our great trouble at this time was with the upola man, as he insisted that the iron would freeze at tapping hole, but we finally persuaded him that he ould not be held responsible should this occur. We drained all the iron out at noon, closing the slag hole with sand, stopping the tapping hole, and shutting all other openings tight, so there would be no draft. About ten minutes before starting time we tapped out all that was in the cupola and pigged it, then put the blast on full, so as to be ready when the starting whistle blew. Sometimes we have to pig 200 or 300 lbs. on account of the metal not being hot enough.

We had two sizes of cupola: 48 and 60 ins. diameter inside the lining. When the heats were heavy we would run the 60-in. cupola. We had to enlarge the plant again, so we took out the 48-in. cupola and installed two new cupolas with 90-in. shells, so that we could line them up to 78 ins. if required. We have them lined at the present time to 70 ins. When running full (night and day) we melt 280 tons, running each cupola about ten hours. We have operated one cupola from 6 p. m. Friday until noon Saturday, closing down at 11 p. m. for half an hour for lunch, and again at 6.30 a. m. for ¾-hour for breakfast. This is rather hard on the lining, so we do not make a practice of it.

We have tried a great many experiments with cupolas, but as yet have been unable to find any that will give better results than the double row of tuyeres, the upper row about 10 ins. above the lower. It is not necessary to keep the upper ones open all the time. Our blast pressure is about 11 ozs. in the cupola bustle. We use a fan for blast. When running full we melt 10 to 11 lbs. of iron to 1 lb. of coke.

In charging the cupola we are very careful to have the charge level. We charge the pig by hand and the scrap is dumped in from a buggy through a door above the regular charging door. All the charges are the same from beginning to the end of the heat. As the iron must come very soft and uniform we do not charge more than 4,000 lbs. at one time. For a smaller cupola, the charge would naturally be less.

From our experiences, I would advise as follows: See that the coke bed is burning even all around, then charge just as you would for an ordinary run, allowing an extra amount of coke for the dinner hour. After running about one hour, open the slag hole and keep it open, except during the dinner hour. Use about 40 to 50 lbs. of limestone to one ton of molten metal, better to use too much than too little. Have the cupola shell large enough, as it is easy to put in an extra lining for smaller heats.

(2) By RICHARD H. PROBERT.*

In the continuous melting of iron in our foundry we operate two cupolas alternately. They are situated side by side, midway and at one end of the molding floors. They were made in our own shops, are drop bottom and of the same size and type. They are 30 ins. diameter inside the lining, and 30 ft. 6 ins. high. The space between the shell and the lining is filled with grout. The last lining put in from the charging door to bottom was on Nov. 21, 1907, and it is still in good condition.

In addition to our continuous melting we make gray iron castings for machine, structural and other lines of work, which is put up on the regular sand floor. These castings are poured each morning before the continuous work is begun. The night watchman lights the cupola at 6 a. m., everything being got in readiness the previous evening. The first iron is tapped out at 7.20 to 7.30 a. m. The first charge of coke to heat up and form the bed amounts to 500 lbs.; we previously charged 900 lbs., but successfully reduced it to 500 lbs. Our charges are small in comparison to those of general foundry practice, but owing to the nature of the work and the continuous melting, the charging of the cupola and frequency of the metal tapped out, all requires nice adjustment to prevent loss.

The charge consists of 100 lbs. of coke and 500 lbs. of iron (about 100 lbs. machinery scrap, 250 lbs. pig and 150 lbs. remelt). The last three coke charges are usually 50 lbs., 50 lbs., and 25 lbs. Limestone will average about 2¼% to the total iron charged. On a day's run of 20 charges, lime rock is commenced with the 5th heat and stopped off on the 15th. This has been closely followed up and no difficulty is experienced. Loss in melting is about 2½% deducting the finished castings and scrap cleaned up from total iron charged.

It is important to keep the molding frames and molds at the highest stage of efficiency, so as not to cause delay in the pouring and the holding back of the iron in the cupola. The frame and mold capacity should be greater than the pouring capacity, which will permit of continuous work. The cupola tender must strictly watch his charges. He must not melt down too fast. The blast must be regulated so the heat is at all times fully known to him. He should keep in close touch with the work on the foundry floor and be ready to give or slack his metal as it is required by the men. Good common sense and strict attention to his duties are required to prevent chilled heats, over heating, and other losses.

Slagging commences regularly each day about 11 a. m. The slag is allowed to accumulate until just below the tuyeres. Our experience is that by leaving the slag at this height we get cleaner iron and better results from the blast. We open the slag hole just enough to let the slag run and by letting this gather in a crust on the outside of the slag hole, it acts as a trough and prevents the blast escaping with the slag.

A circular revolving molding frame is very convenient and can be worked to advantage on standard lines of duplicate work, in which the molds are self-contained and separate unto themselves. Such an arrangement would permit of the iron-pourer getting around his work quickly besides leaving sufficient room for more than one man to pour iron on the job at the same time.

*Louisville, Ky.

Our permanent molds are largely for ornamental work, some of them are made to hinge and are provided with a swivel clamp set into a lug on the side of mold for fastening the two halves together, others are not hinged and are fastened together with screw clamps or gib and key. Any arrangement made for the fastening of the mold together should be made so the same can be taken apart easily and quickly, as it is necessary to open up the molds as soon as poured, in fact while the casting is at a very bright red heat.

Continuous melting can be easily arranged for, and with an equipment of overhead runways and hoists, the frames can be quickly changed. The molds on all frames can be previously got ready by the mold makers, so that very little time is lost in changing frames. It is advisable to have a few extra sets of stanchions for all preparatory work to be set up on them, thereby preventing delay.

A mixture of linseed oil and powdered soap stone or of oil and graphite swabbed on the molds and gates each heat will prevent the castings sticking and prolong the life of the molds. The molds should be kept clean and when not in use stored away on shelves convenient to the molding frames.

We use high-carbon steel molds that have sharp, thin edges on the inside. In constant use the steel in these molds roughs up, but does not eat away and burn off like the cast-iron molds.

By this process, with the proper mixture of metals carefully melted, and well made permanent molds that will stand up to the work required of them, with instant effective pressure on the molds as soon as the molten metal is poured into them, cast specialties can be made with increased strength. The pressure will make them non-porous, more dense in structure, which the annealing would not weaken but rather toughen. Subjecting some cast specialties to pressure would make them more suitable for the finer line of machine parts, as they would be pressed into better shape, be cleaner, and with their parts more clearly defined. An equipment for such added pressure can be easily made, and after first cost would be a slight expense in operation.

FIG. 7. LAST SECTION OF THE LAGUNA DAM TO BE CONSTRUCTED; ACROSS RECENT RIVER CHANNEL.

(View taken from California shore, looking towards Arizona, March 14, 1909.)

A Comparison of Mean Sea Level at Quebec and New York.*

By W. BELL DAWSON,† D.Sc., M. Inst. C. E., F.R.S.C., M. Can. Soc. C. E.

The following information and deductions with regard to Mean Sea Level at New York compared with its determination at Quebec will prove of interest; as it affords a relation which has long been desired by engineers to bring our levels along the St. Lawrence, including the harbors of Quebec and Montreal, into relation with the open Atlantic.

The result is based on a long series of tidal observations at Quebec obtained by the Tidal and Current Survey, under the direction of the author, and on the levels of the Georgian Bay Canal Survey, under the direction of Mr. A. St. Laurent, C. E., the field work being in charge of Mr. C. F. X. Chaloner.

The comparison is based upon the elevations of the sill of Old Lock No. 1 of the Lachine Canal, at the head of Montreal harbor, where the levels meet which have now been carried through from New York via Rouses Point, and along the St. Lawrence from Quebec by Mr. R. Steckel, C. E., of the Public Works Department, by the geodetic series taken previous to 1891.

The tidal observations at Quebec have been obtained by a registering tide gage situated at the Dry Dock at Levis, which gives a continuous record day and night throughout the year. They are reduced throughout to the Admiralty Low Water datum at Quebec, as used for the chart of Quebec harbor. This datum has also been adopted by the Tidal Survey as the plane of reference for the Tidal Tables for Quebec. It is defined by the Admiralty in its own publications as 28.00 ft. below the Bench Mark cut on the east side of the principal gateway to the Marine and Fisheries building in Quebec.

The various connections by means of which the reductions are made, are as follows: From the Admiralty Bench Mark in Quebec to the Levis dry dock where the tide gage is situated, connected by Mr. Steckel's levels across the river; one of his Bench Marks being set in the masonry of the dry dock. From Levis to Montreal, connected by Mr. Steckel's levels. From Montreal to Rouses Point, from the levels of the Georgian Bay Canal Survey, which there connect with the levels of the U. S. Coast and Geodetic Survey from New York. The elevation taken for the Coast Survey Bench Mark at Rouses Point is the revised value of 1903. As explained in Mr. St. Laurent's report, the elevation of this Bench Mark is based upon a readjustment made in that year by the U. S. Coast Survey, and is now accepted as 107.955 ft. above Mean Sea Level, instead of 110.06, as used before the 1903 determination. The difference between Mr.

*A paper read before the Canadian Society of Civil Engineers, Nov. 19, 1908.

†Engineer in charge of Tidal Survey, Dept. of Marine, Ottawa, Canada.

Steckel's datum and that of the Georgian Bay Canal Survey, is based on a common Bench Mark at St. Lambert.

Admiralty Bench Mark at Quebec, as above described	28.00
Sill of Old Lock No. 1, Lachine canal. Difference of level as determined by Mr. R. Steckel, 15.50 ft. below the Admiralty Bench Mark at Quebec. Resulting elevation	12.50
Mean Sea Level, or half tide at Quebec, as determined at the Levis dry dock; from the hourly ordinates of the tide during eight years of continuous observations, from 1894 to 1902. Mean of the eight years, 8.584 ft. above the Admiralty datum	8.58
(The value adopted by the Royal Engineers in 1864, for mean sea level in Quebec harbor, corresponds to 8.72 ft. above the Admiralty datum. This would be somewhat further up the river than the dry dock.)	
Mean Sea Level at New York determined by the Georgian Bay Canal Survey, as 5.38 ft. below the sill of Old Lock No. 1, Lachine canal	7.12
Steckel's datum referred to the Admiralty datum; the elevation of the Admiralty Bench Mark above his datum being 27.039 ft.	0.96
Admiralty Low Water datum at Quebec; adopted as the datum for the Tidal Survey	0.00

It thus appears that Mean Sea Level or half tide at Quebec, when accurately determined by tidal observations, is 1.46 ft. above Mean Sea Level at New York.

Note.—With regard to this determination, it may be noted that the method of determining Mean Sea Level by the summation of hourly ordinates is equivalent to taking it at the level of the horizontal line which bisects the area of the tide curve. This is the most accurate way of dealing with a river tide, in which the rising side of the curve is steeper than the falling side.

Also, it is found from precise observations that there is a variation in Atlantic Mean Sea Level from year to year, which is possibly periodic in a term of years. For strict accuracy, such a comparison as this should therefore be made during the same set of years at both places. As the re-determination of the elevation of the Bench Mark at Rouses Point was made in 1903, this should make the comparisons practically simultaneous, as regards the years on which the data are based.

There are no other known sources of error which affect the result, within the limits of accuracy in geodetic levelling.

Pile-and-Cylinder Foundations of Norfolk & Western Bridge No. 5, Elizabeth River, at Norfolk.*

By J. E. CRAWFORD,† M. Am. Soc. C. E.

Bridge No. 5 of the Norfolk & Western Ry. crosses the East Branch of the Elizabeth River about half a mile south of Norfolk (Va.) passenger station. This bridge was rebuilt last year, for heavier traffic. Its history illustrates the great strides which have been made in transportation facilities, both rail and water.

First Bridge.—The first bridge at this site, a single-track structure, was built by Mr. William Mahone, Chief Engineer of the Norfolk & Petersburg R. R., in 1856. It consisted of three 200-ft. Fink truss through spans and one 48-ft. jack-knife draw-span giving a clear waterway of about 40 ft., and carried safely train loads up to 1,800 lbs. per lin. ft. of track. These 200-ft. spans had cast-iron compression members and wrought-iron pin-and-link tension members, and were supported at the ends by granite posts. Each pier was of granite ashlar masonry, built on an 18-in. timber crib which rested on 150 pine piles cut off 22 ft. below low water, or a little below the river mud. Each pile carried a total load of six tons. The piles were spaced 2½ ft. on centers in each direction, and between the rows of piles were placed 12-in. timbers crossing each other at right angles and dapped and driftbolted to each other. There was no mortar between the stones of these piers below low water that was apparent on their removal. I am informed that the piles were cut off and the piers built under a diving bell and without the use of a cofferdam or watertight caisson.

Second Bridge.—The original bridge carried traffic for 32 years, the last four years of which it was trestled. It was replaced in 1888 by one 48-ft. deck lattice span, two 200-ft. through Phoenix truss spans and one 200-ft. through swing-span giving two clear waterways of 70 ft. each, carrying safely train loads up to 5,000 lbs. per lin. ft. of track. This bridge was erected on the old masonry, except that a new center pier was built for the draw-span. This new center pier was built of ashlar masonry in a heavy timber floating caisson 36 ft. square, which was sunk by the increasing weight of the new masonry, on to a foundation of 169 piles, which had been driven and cut off 18 ft. 6 ins. below low water. These piles were spaced 3 ft. apart in each direction and carried 6 tons each.

Third or Present Bridge.—The second bridge carried traffic for 20 years, until 1908, when the present new double-track bridge was put in. This consists of three 90-ft. and two 94-ft. through plate-girder spans, one 44-ft. Scherzer pier span and one 160-ft. Scherzer lift span, giving a clear waterway of 140 ft., capable of carrying safely a load of 15,000 lbs. per lin. ft. per track.

It is interesting to note that each time the bridge was rebuilt the clear waterway was doubled and the capacity was about trebled.

General Design.

Bridge No. 5 is right in the throat of Norfolk Yard, and there is scarcely five minutes of the day when there is not a train on the bridge, shifting or otherwise. The traffic on the river is also heavy, an average taken for 30 days requiring 28 openings of the draw per day. Owing to the depth of soft bottom, and the cost of changing yard tracks and of acquiring additional right of way, it was found that a temporary run-around trestle with temporary draw-span would be excessively costly; it was therefore decided to put in the new piers and superstructure on the site of the old bridge without interfering with traffic either over the bridge or through the draw. To this end, twin cylinder piers and some type of lift span were necessary. The lift span was also deemed advisable, since it permits of placing a twin bridge alongside when additional tracks become necessary, whereas a swingbridge is a total loss when additional tracks must be provided. The lift-bridge is also quicker in operation, and the War Department favored this type. On actual tests the bridge opened in 40 sec using 55 HP.

Foundations.

The river bottom is composed of about 10 ft. of soft river silt overlying stiff blue mud and sand in layers of varying thickness, and in many instances very hard

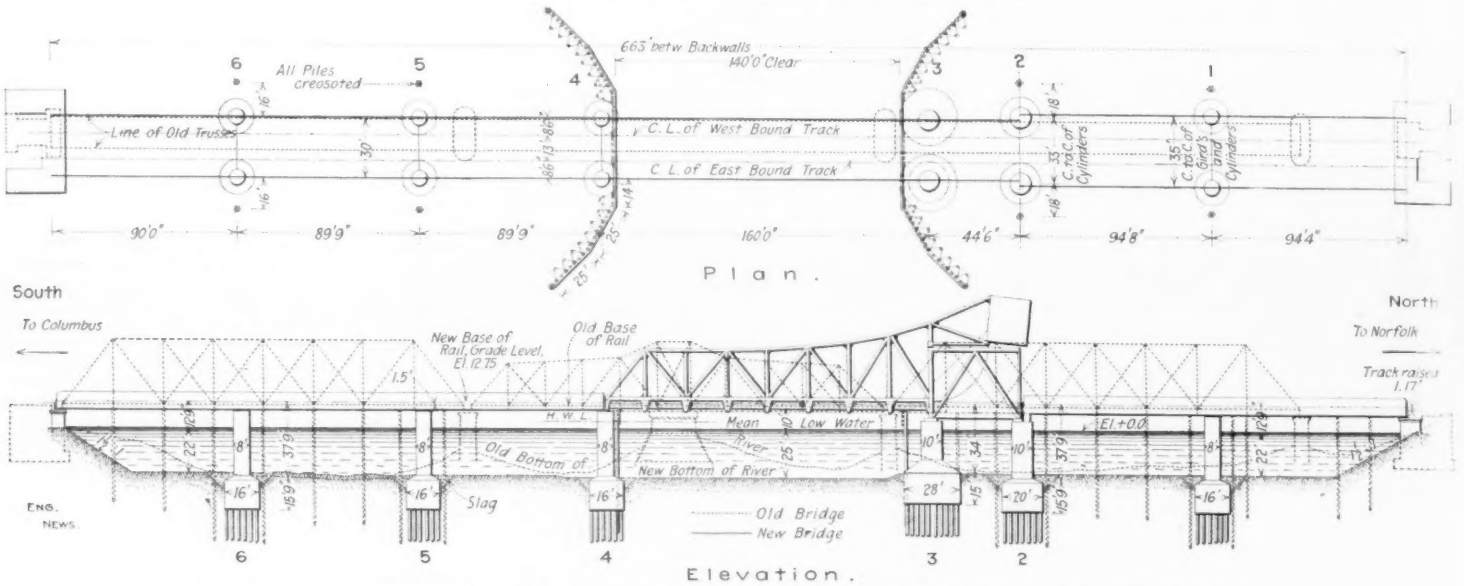

FIG. 1. NORFOLK & WESTERN BRIDGE NO. 5, EAST BRANCH OF ELIZABETH RIVER AT NORFOLK, VA.
Plan and Elevation of Old and New Bridges.

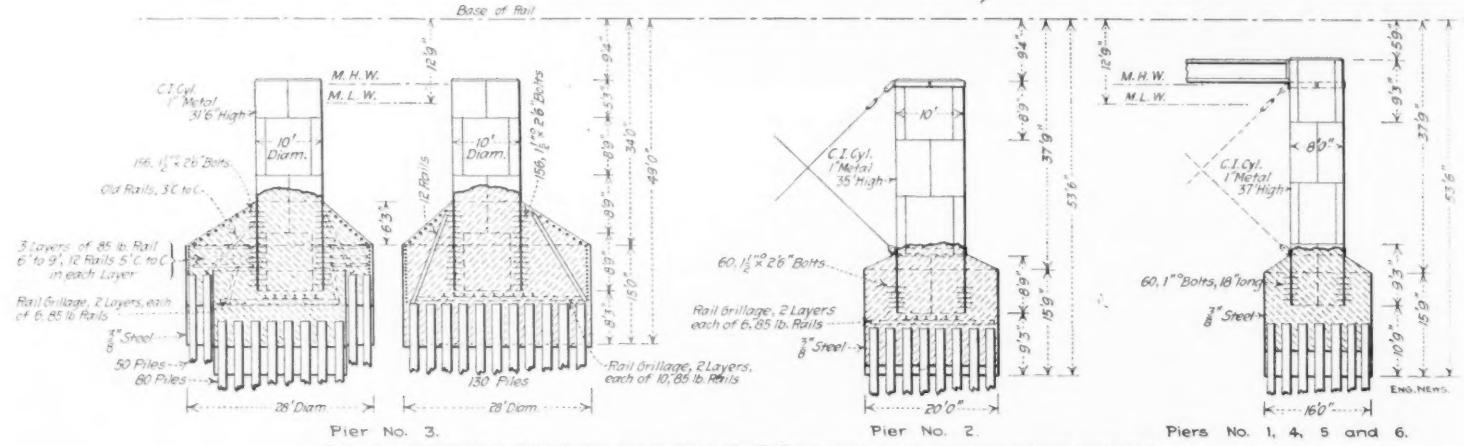
Base of Rail
M. H. W.
M. L. W.
C.I. Cyl. 1" Metal 31'6" High
10' Diam.
156, 1½" × 26" Bolts
Old Rails, 3'C. to C.
3 Layers of 85 lb. Rail 6' to 9', 12 Rails 5'C. to C. in each Layer
Rail Grillage, 2 Layers, each of 6, 85 lb. Rails
⅞" Steel
50 Piles
80 Piles
28' Diam.
12 Rails
130 Piles
Rail Grillage, 2 Layers, each of 10, 85 lb. Rails
C.I. Cyl. 1" Metal 35' High
60, 1½" × 26" Bolts
20'0"
C.I. Cyl. 1" Metal 37' High
60, 1" Bolts, 18" long
⅞" Steel
16'0"
ENG. NEWS.
Pier No. 3.
Pier No. 2.
Piers No. 1, 4, 5 and 6.

FIG. 2. CYLINDER PIERS ON PILE FOUNDATIONS, NEW ELIZABETH RIVER BRIDGE.

*Slightly condensed from a paper read before the Engineers and Constructors' Society of Tidewater, Va., in February, 1909.

†Bridge Engineer, Norfolk & Western Ry., Roanoke, Va.

this formation extending to a great depth (about 1,600 ft.). The water is 22 ft. deep at mean low water; the tide range is 3 ft.

To decide upon the load which this foundation would safely carry was the first and most uncertain problem presented. We knew that piling must be used, and the problem then resolved itself into three general subdivisions.

1. What is the safe load per pile?
2. What is the safe load per square foot of piled area?
3. How may lateral stability be secured?

We first turned to books, engineering publications, and papers of the various engineering societies, confident that we could find many precedents to guide us. After spending a great deal of time we found ourselves swamped in a sea of literature in which the key to the situation failed to disclose itself. Full and complete records of similar foundations failed to materialize, and we were forced to piece together incomplete precedents into a conservative whole. We might drive and load test piles and test the bearing value of the soil, but we could not, without prohibitive expense, reproduce even approximately the conditions imposed on the full-size pier foundation. We must, therefore, gather together and depend on precedent, local and otherwise.

PRECEDENTS FOR PILE LOADS.—1. The piles under the old piers at Bridge No. 5 carried only six tons each, but were driven only 32 ft. below the river bottom, whereas we proposed to drive the piles under the new piers from 40 ft. to 50 ft. into the stiff mud and sand.

2. Turning to our records of the substructure of our Lambert's Point coal pier No. 3, completed in the year 1901: This consists of 50 steel-plate cylinders, ⅜-in. thick and 34 ft. long, sunk so that the tops are 12 ins. above high water. Forty-two of the cylinders are 10 ft. and eight are 8 ft. in diameter, the latter being all at the river end. These cylinders were delivered entirely put togther, and by means of derrick barges were taken from cars and stood on end at their proper locations. It was then necessary to sink them in blue mud and sand formation, 30 ft. at the bulkhead end and 11 ft. at the river end. This was done by pulling down with heavy blocks and tackle attached to two sides of the cylinder, the power used being two pile-driver engines. Three water-jets were also used to cut mud away from the outside of the cylinders. By this method about half of the cylinders were sunk to the proper elevation, but for the others it was necessary to dredge out the inside before getting them down. This was done by using a small one-yard clamshell dredge.

After sinking the cylinders as above, they were dredged out to their full depth, and untreated Virginia pine piles were driven. There are 14 piles in each 8-ft. cylinder and 20 piles in each 10-ft. cylinder. All piles were driven with a 3,000-lb. hammer, falling 10 ft. The piles ran from 70 to 90 ft. in length, the average being about 80 ft. The penetration of the first pile driven in a cylinder under the last blow of the hammer averaged 3 ins. The penetration of the last pile driven in a cylinder under the last blow of the hammer averaged 1½ ins. The maximum load on these piles is 14 tons per pile.

These piles were either driven to or cut off at low water mark, which is 4 ft. below the top of the cylinders. The cylinders were then pumped out, as low as possible, and filled with concrete made with 1 part Commercial Rosendale cement, 1½ parts of sand and 3 parts of oyster shells. Care was taken that no piles should be within 6 ins. of the side of the cylinders, and the concrete was carefully filled and rammed in all spaces and between the cylinders and piles. This concrete was built up to the tops of piles or low water. Above this the cylinders were filled with concrete made of 1 part Lehigh Portland cement, 2 parts sand and 5 parts broken granite, and topped with a smooth finish of cement and sand in equal parts, at an elevation of 18 ins. above high water, or 6 ins. above the tops of cylinders. Four anchor bolts, 1¾ ins. diameter by 4 ft. long, were bedded in each cylinder. Salt water from the river was used in mixing all concrete. No settlement whatever occurred in any of these piers.

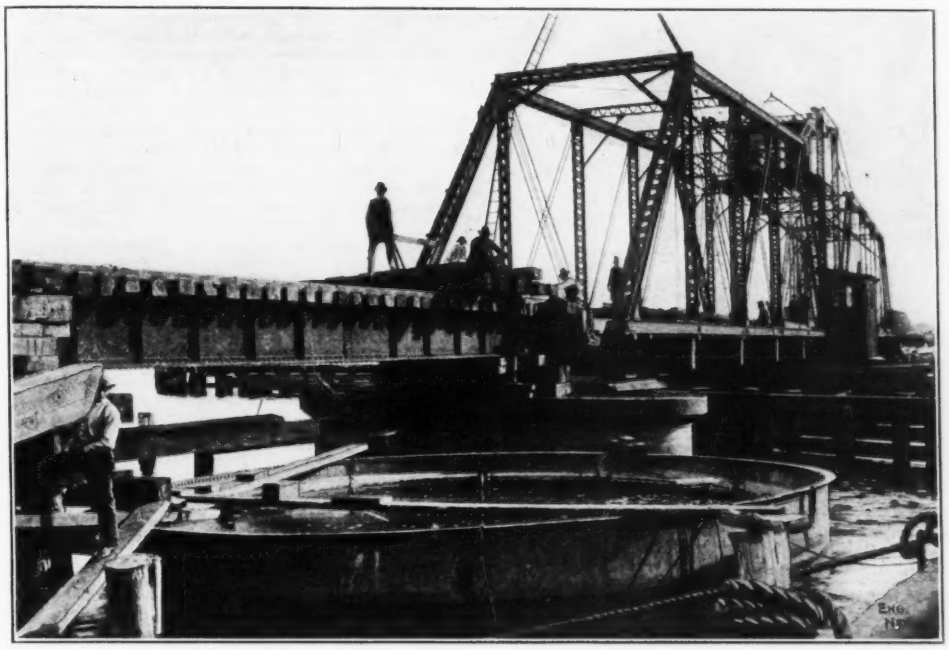

FIG. 3. ENLARGEMENT CYLINDER FOR FRONT TRUNNION PIER, ELIZABETH RIVER BRIDGE.

3. The old center pier under the 135-ft. deck girder draw-span over the South Branch of the Elizabeth River 6 mi. from Norfolk was built in 1888, as follows: Ten piles were driven on the perimeter of a 10-ft. circle and cut off 24 ft. below low water, this being a couple of feet below the mud line. On these piles was set a 10-ft. cast-iron cylinder 24 ft. long, and in this cylinder seventeen piles were driven into hard sand and mud. The cylinder was then filled with concrete. The piles in this pier carried safely 17½ tons of each and were subjected to excessive vibration under this load, due to the narrow base of the piers, 10 ft.

4. The end piers under the 135-ft. draw-span above mentioned carried also one end of a 140-ft. through span. They consisted of twin 6-ft. cast-iron cylinders 23 ft. long, each having seven piles driven in it surrounded by concrete. Each of the piles carried 26 tons and was also subjected to excessive vibration under this load due to the narrow base (6 ft.), of the pier. These piers you will note were 23 ft. high.

CONCLUSIONS.—With the above figures before us, we felt safe in using 75-ft. Virginia pine piles, driven to good refusal, and loading them to 12 tons each, and the piers for Bridge No. 5 were designed on this basis.

I note that there is a pretty general working rule among engineers throughout this country to allow a a load of 20 tons each on all piles driven to practical refusal—that is, until the pile does not penetrate more than ½-in. under a 2,000-lb. hammer falling 15 ft. I find that the Engineering News formula gives good safe working loads. The falsework piles were driven with a 3,300-lb. hammer falling 10 ft. They were 70 ft. long and had a penetration of about 40 ft. The average penetration at the last blow was 2 ins., and by the Engineering News formula the safe load was 11 tons. These piles, however, carried safely 24 tons per pile, and it required a pull of from 30 tons to 35 tons to pull them out.

SOIL LOADING.—We estimated that we could safely load this foundation to 3 tons per square foot of piled area, which allowed us to drive one pile (carrying 12 tons) in each 4 sq. ft. of area of cross-section of our cylinder piers. From Mr. E. L. Corthell's recently published book, "Allowable Pressures on Deep Foundations," page 7, I note the following pressures obtaining in existing structures:

On alluvium and silt, 1.5 tons to 6.2 tons, with an average of 2.9 tons for seven examples.

On fine sand, 2.25 tons to 5.8 tons, with an average of 4.5 tons for ten examples.

On sand and clay, 2.5 tons to 8.5 tons, with an average of 4.9 tons for ten examples.

These figures indicate that our load, 3.0 tons per sq. ft., is quite safe.

Pier Construction.

The general layout and construction of the piers is shown in Figs. 1 and 2. These piers are laid out so as to come between the panel-points of the old 200-ft. spans, so that, the iron floorbeam at each panel point being supported by a pile bent, the trusses could be taken down to allow placing the new downstream cylinders, and the old iron stringers could still carry traffic. The upstream line of cylinders came outside of the old trusses and could be placed without interfering with the old structure. The downstream cylinders, however, came under the old trusses and extended underneath the track, so that it was necessary to take the trusses down and shift the track about 7 ft. upstream before the cylinder caissons could be set and piles driven. This shift of track necessitated the maintenance of a 20° reverse curve at each end of the old draw. It was also necessary to raise the track 18 ins., which further complicated the work.

I will describe the two piers carrying the Scherzer span as being typical of the whole.

Each pier consisted of two 20-ft. steel cylinders 15 ft. 9 ins. long, of ⅜-in. metal, stiffened against distortion by 3½ × 3½-in. angles spaced 5 ft. apart vertically. These cylinders were attached to a temporary upper caisson of the same diameter and long enough to reach above high water, and were set with their bottom or cutting edge about 40 ft. below low water and about 18 ft. below the river bottom. One 20-ft. cylinder with its temporary caisson weighed 30 tons, and was easily handled by the 100-ton capacity U. S. Navy derrick boat. They were set in a square guiding frame and located quite accurately. They sank of their own weight to within a few feet of the proper depth, when picking them up and dropping them a couple of times would bring them down.

These cylinders were then dredged out to their full depth and 80 piles were driven in each. The piles were then cut off by a diver at a point 7 ft. above the cutting edge of the cylinder, a good diver cutting about eight piles a day. The cylinder was then sealed by placing, under water, a 5-ft. layer of 1:2:4 Portland cement concrete around the piles and up to a point 6 ins. below their heads. This was deposited by a 1-yd. drop-bottom bucket, which was lowered down to the heads of the piles and dumped by a diver so as to allow the full bucket load to be deposited with the least fall through the water, and to prevent, as far as possible, any circulation of water through the mass of

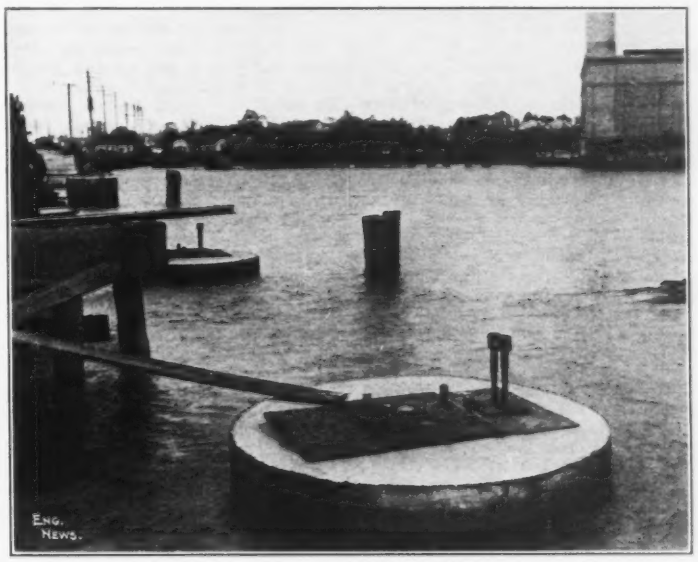

FIG. 4. UPSTREAM TRUNNION PIERS OF ELIZABETH RIVER BRIDGE READY FOR TRACK GIRDERS.

the concrete. This concrete was allowed to set for four or five days, and then the cylinder was pumped out. The concrete was found to be well set but coated with a soft white deposit three or four inches deep, which had not set up. After this deposit had been cleaned off, a layer of concrete about two feet thick, reinforced by a grillage of rails, was placed over the heads of the piles.

FIG. 5. ERECTION OF LIFT SPAN, NEW ELIZABETH RIVER BRIDGE.
(Traffic maintained over old swingbridge through tail of lift span.)

On this foundation a cast-iron cylinder 10 ft. in diameter and 35 ft. long, weighing about 25 tons, was set by the Navy derrick boat. These cylinders were cast at the Norfolk & Western foundry at Roanoke and were made in four 8-ft. 9-in. lengths, each length being made in four segments, the whole well bolted together by ⅞-in. bolts through inside flanges. The shell is 1-in. thick.

Cast-iron was used rather than rolled steel because of its superior lasting qualities when wholly or periodically immersed in salt water. When removing the old cast-iron piers recently at our bridge over the South Branch of the Elizabeth River, six miles from Norfolk, this quality was very strikingly illustrated. These cast-iron cylinders were 1¼-in. thick and had been in service for 20 years in brackish water without any decrease in thickness, and the fracture showed throughout a good quality of clean gray iron.

The 20-ft. steel cylinder was then filled with 1:2:4 Portland cement concrete up to the joint between it and the temporary caisson, and this was crowned up to a 30° slope around the cast-iron cylinder. The cast-iron cylinder, thus imbedded in concrete for a depth of 9 ft., was then filled inside with concrete up to within a couple of feet from its top. Sixty 1½-in. round iron bars 2½ ft. long were run through the cast-iron cylinder near its bottom to thoroughly anchor it to the concrete and to tie the masses of concrete inside and outside of the cylinder together. Finally, a heavy beam grillage was set in the cast-iron cylinder, making the bridge-seat 3 ins. above the top, and the whole was crowned and grouted with concrete.

The concrete used was mixed with a Smith mixer. Norfolk sand and salt water were used in the concrete. Standard briquettes gave the following tensile strengths, in lbs. per sq. in.:

Standard Sand and Laboratory Water. 7 days: 260, 263, 290; 28 days: 360, 373, 400.

Norfolk Sand, Elizabeth River Water. 7 days: 330, 290, 336; 28 days: 310, 360, 300.

Standard Sand and Elizabeth River Water. 7 days: 259, 260, 261; 28 days: 350, 380, 380.

Norfolk Sand and Laboratory Water. 7 days: 300, 290, 330; 28 days: 340, 315, 373.

In the 7-day tests salt water gave the same strength as laboratory water and Norfolk sand gave greater strength than laboratory standard sand, which consists of ground quartz. In the 28-day tests the fresh water gave a little greater strength than the salt water, and the standard sand greater strength than the Norfolk sand.

After the concreting in the cast-iron cylinder was completed, the caisson, which had been kept pumped dry, was allowed to fill up through a hole near the top, and was lifted off and bolted to another permanent cylinder to be set elsewhere. A very satisfactory water-tight joint was secured between the permanent cylinder and the caisson. The caisson was made with its inside diameter ½-in. greater than the outside diameter of the permanent cylinder. Connection was made by bolting between two horizontal inside angle flanges, between which was placed a 1-in. round rubber gasket. This gasket was compressed to about ½-in. thickness by the weight of the caisson, and thus any irregularity of the steelwork was filled up. The web of the caisson projected several inches below and outside of the web of the permanent cylinder.

After the pier was completed and before the caisson was filled with water, the bolts holding it to the permanent cylinder were taken out and several special cast-iron clamps were put on, each clamp being attached to a long pipe wrench. After the caisson was filled and when the derrick boat was ready to lift it off, these clamps were released and drawn out by the pipe wrenches.

When these piers were originally planned, the intention was to dredge the cylinders inside to 5 ft. from the bottom, drive piles in them, pump out, cut off the piles and place all concrete in air. This would save the cost of cutting the piles under water and the cost of the concrete for sealing. The first pier was completed in this manner, and without serious difficulty, though there was some rising of mud in the bottom, which was dug out, the bottom being sealed with a couple of feet of concrete, half of the pier at the time. The next two piers gave considerable trouble. In one of them the bottom broke through with a rush after the piles were all cut off, and buried them in eight to ten feet of sand and mud; this was pumped out with a suction dredge, at considerable expense, and the pier completed. The other was not so troublesome, but a spring of fresh water broke through, carrying fine white sand. These troubles decided us to cut the piles by diver and seal the bottom as above described before pumping out the piers. In each case the unsealed bottom stood for four or five hours, and in one case several days, without leaking. It was found, however, impracticable to cut the piles and seal the bottom fast enough to prevent water, sand and mud from rising in the cylinder after it had been pumped out.

Reinforcing of Pier No. 3.

When Pier No. 3 had progressed so far that one 20-ft. cylinder was set and sealed, we found that the weight of the Scherzer span would over-run the estimate of the Scherzer Rolling Lift Bridge Co., and that the piles would be loaded to 18 tons each. We decided, therefore, to increase the number of piles from 80 to 130 per cylinder, thereby decreasing the load from 18 tons per pile to 12 tons, our adopted safe load. A 28-ft. cylinder was therefore set around the 20-ft. cylinder already placed and 4½ ft. higher up, fifty piles were driven in the 4-ft. ring between the cylinders and cut off by a diver flush with the top of the 20-ft. cylinder. The 4-ft. ring was then sealed by concrete placed under water, the 28-ft. cylinder pumped out, and the pier completed. Ample rail and rod reinforcement was placed in the concrete around the cast-iron cylinder to insure the load being distributed equally over the piles.

In placing the 28-ft. cylinder on the downstream side it was necessary to cut through 5 ft. of granite footing courses and 18 ins. of cribbing of the old draw pier, and to pull eleven of its piles. From a platform, using long drills, a circular line of holes was drilled through these courses, which were from 14 to 22 ft. below the surface of the water. These holes were loaded by a diver and a segment of these courses were blown out. This material was then dredged out and the piles were pulled. The piles had a penetration of 32 ft. and both piles and cribbing, which had been in the pier since 1854, were sound.

Pile Driving Notes.

The piles in the new piers were driven with a No. 2 Vulcan steam hammer, striking about sixty blows per minute. The weight of the hammer was 3,000 lbs., normal fall 3 ft., effective fall 2 ft. 6 ins., and the weight of the hammer and housing resting on the pile at all times was 6,000 lbs.

The data obtainable as to the safe load on piles driven with a steam hammer were meager, and we decided to drive these piles until it took 30 blows of the above hammer to secure a penetration of one inch. The actual resistance secured was not quite as great as this; the average of all the piles driven required 25 blows to secure the last inch of penetration.

The first six piles driven in one of the 20-ft. cylinders were driven by a 3,300-lb. drop hammer falling 10 ft. The average total penetration secured was 28 ft. and the average penetration at the last blow was ½-in. Compared with this the first six piles driven in the next 20-ft. cylinder (44 ft. away) were driven with the 3,000-lb. steam hammer, falling three ft. The average penetration secured was 26 ft. and the penetration for the last 100 blows averaged 7 ins. for the six piles or fourteen blows to the inch. The first six piles driven in the twin 20-ft. cylinder to the cylinder first mentioned and only 33 ft. away from it, were driven with the steam hammer, the average penetration secured was 36 ft., and the penetration for the last 100 blows averaged 7 ins. for six piles, or fourteen blows to the inch.

At our bridge over the South Branch the last 28 piles out of 80 in a 20-ft. cylinder were driven with a 3,300-

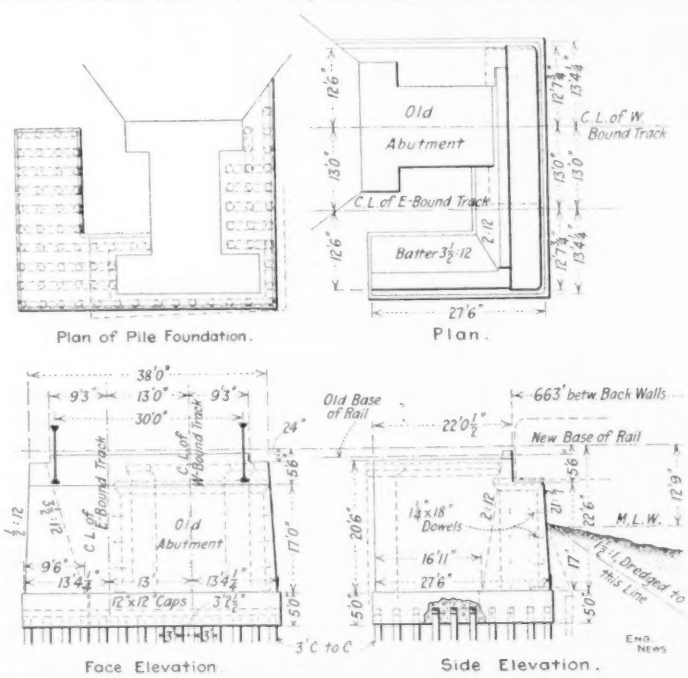

FIG. 6. WEST ABUTMENT OF NEW ELIZABETH RIVER BRIDGE.
(The new concrete work surrounds and incorporates the old cut-stone abutment. Hook anchors tie the two parts together.)

lb. drop hammer, falling 10 ft. The average total penetration secured was 18½ ft. in hard white sand, and the average penetration under the last three blows was $^{5}/_{16}$-in. per blow. The first 52 piles driven in this cylinder were driven with a 3,000-lb. steam hammer falling three ft., the average total penetration was 24½ ft. per pile, and the average penetration for the last 100 blows was 2 ins., or fifty blows per inch. The ten piles driven just previous to those driven with the drop hammer, or piles 43 to 52 inclusive, which were driven by steam hammer, average total penetration 19½ ft., penetration at last 100 blows, 1-in. The last 28 piles of 80 driven in the twin 20-ft. cylinder of the above, 33 ft. away, were driven with the steam hammer, and averaged total penetration 21½ ft., penetration at the last 100 blows ⅝-in.

Considering the above figures and records elsewhere, I have adopted the following modifications of the Engineering News formula, as giving safe loads for piles driven by steam hammer:

$$\text{Safe load} = \frac{2\,W\,H}{S + {}^{3}/_{10}}$$

where W = Weight of hammer
H = Fall in feet
S = Penetration under last blow, in inches.

It is noteworthy that the total penetration secured per pile was about the same when driving with the drop hammer as with the steam hammer. The drop hammer broomed the heads of the piles and no increase in penetration was secured by increasing the drop above 10 to 15 ft. With the steam hammer no brooming occurred and the full force of the blow was effective at all stages of the driving. It is interesting to note the effect of a heavy (3,800-lb.) drop hammer on 34 piles driven in the temporary trestle at our Greveport Pike Undercrossing, near Columbus, O. (See Engineering News, Jan. 14, 1909, page 44, an illustrated article by Julian Griggs): 13 piles, or 38%, were more or less damaged by driving and several of them even telescoped, buckled and bent almost past belief and beyond any load-sustaining value. We have noted this mangling of piles by a drop hammer elsewhere, and are therefore inclined to favor the lighter quick blows of the steam hammer.

All the piles driven were untreated Virginia pine, averaging 70 ft. in length, with not less than 14-in. butts and 7-in. points. The piles were driven in about 38 ft. of water, about 16 ft. of the soft silt having been dredged out, so that all the penetration secured was through the firm mud and sand underlying this silt.

The average penetration secured for all the piles driven in the piers was 31 ft., the minimum penetration was 12 ft. and the maximum penetration was 56 ft. For the latter the point of the pile was 94 ft. below low water, and a follower was necessary. The penetration secured, even in the same cylinder, showed remarkable variation, the maximum penetration in any cylinder being generally about three times as great as the minimum penetration in the same cylinder. The penetration for the last five piles driven in a cylinder averaged 24% less than the penetration for the first five piles driven in the same cylinder. Where a follower was necessary on account of the pile head being below the water, this follower was held firmly in line and no immediate decrease in penetration was noticeable, indicating that there was no appreciable loss in the effect of the blow.

A typical pile drove as follows: The pile sank of its own weight 6 ft.; then the hammer and housing, weighing 6,000 lbs., was put on it and it sank 5 ft. further. The number of blows required for each succeeding foot of penetration were 9, 5, 13, 20, 14, 16, 17, 15, 30, 40, 47, 65, 45, 26, 22, 33, 60, 55 and 55. Then the follower was put on and the number of blows required per ft. was 55, 75, 56, 60, 73, 90, 113, 115, and 102 blows for the last seven inches, giving this pile a penetration of 39 ft. 7 ins.

Horizontal Stability of Piers.

Horizontal stability of the piers was secured by the low cutoff of the piles, and by dumping about 6 ft. of slag around the cylinders. These piers were severely tried soon after they were completed. A large seagoing tug ran into the 95-ft. approach span just north of the lift span, with such force as to shift this entire span, weighing with its deck 500,000 lbs., one inch on the bedplates. The piers were undamaged, however. We braced the two cast-iron cylinders of each pier together with 2½-in. round rods with turnbuckles attached to 10 × ⅝-in. circular yokes at the bottom and top of the cylinders.

Abutments.

The old single-track ashlar masonry stem-wall abutments were incorporated in the new concrete U-abutments, as shown by Fig. 6, and were bonded to it by 1¼ × 18-in. hook bolts about 4 ft. apart. A rectangular cofferdam of United States steel sheet piling was driven around this abutment, and well into the bank at the back. This was dredged out and the piles were driven with a 3,300-lb. drop hammer falling 10 ft. They had an average total penetration of about 50 ft. in mud and sand, and a penetration of 3 ins. total for the last three blows or 1 in. per blow. The first cofferdam was then pumped out with the intent of cutting the piles and placing the concrete in air. It leaked very badly, however, at several points in the bottom and alongside the old pier, and we were unable to control the water. We then decided to have the piles cut off by a diver, and to seal the bottom of the cofferdam with concrete around the heads of the piles and placed under water by a diver from a drop-bottom bucket. This latter method was similar to that adopted for the piers and proved quite satisfactory.

Removing Old Piers.

The old piers were removed by drilling from top to bottom and breaking them up by charges of dynamite, when the pieces were made fast by a diver and lifted out with a floating derrick. We were much surprised to find that the old crib from the center pier, which was 4 ft. thick, of 12 × 12 pine timber, and had been in the water twenty years, floated high in the water, and was apparently just as light as when first placed.

There were 169 piles under this crib with their tops 18½ ft. below low water. The War Department required 22 ft. of water, but we decided to cut them off 25 ft. below low water. This was an expensive operation on account of the mud which adhered to the piles and could not be dredged out. A diver, working in conjunction with a suction dredge, could only cut about four piles per day. We were afraid to let water down to our new foundations by pulling this large cluster of piles. In this connection it is interesting to note that at the South Branch bridge piles were broken square off by placing a couple of sticks of dynamite close alongside the pile. There was some little concrete around these piles, which probably stiffened them against the explosion.

The work above described was carried on under the direction of Mr. Chas. S. Churchill, Chief Engineer, and Mr. C. C. Wentworth, Prin. Asst. Engr., and under the supervision of Mr. F. P. Turner, Resident Engr. The Contractors for the substructure were J. P. Pettyjohn & Co. The superstructure was built by the Pennsylvania Steel Co. The writer was in charge of the design of both the substructure and the superstructure.

Some Comments on Our Engineering Education and the Men It Produces.*

By W. D. TAYLOR.†

During the five years spent in the University [of Wisconsin] and ending three years ago I listened to a number of engineering lectures arranged for by the University by a number of eminent engineers and managers of great industrial corporations. Some of these lectures were to me very interesting but many of them were quite the contrary. Those that did not very much interest me were generally made by some expert in some particular kind of engineering work who generally knew quite well how to do his engineering work but not so well how to interest a body of students.

There were many of these lectures that I was sorry that I attended, many of them being, for the most part, bare recitals of the outlines of machines that had been used to effect this or that end, or lectures in which the author made a laborious undertaking of the description of the minutest details of the methods by which some great work had been accomplished. There was one thing about the attention that the students gave these lectures that was quite remarkable and that was that where a man discussed a real live question, such as how to get a water-supply out of one valley through a chain of mountains to a city in an adjacent valley, the students always sat up and gave alert attention.

But whenever the same lecturer began to use his lantern slides to show how every little detail of a piece of work was carried out interest immediately lagged and watches were consulted to see how much was left of the hour. I often noticed the same phenomenon in teaching my own classes until I got experience enough to at least try to omit details and methods as far as possible and to confine my instruction to principles and to a discussion of the broader questions connected with each subject.

Perhaps you will say that as an engineering instructor I ought to have taken an active interest in all these things and perhaps you are right. But I want to say that I have found that I can't do it all. I have found that I am a man of very ordinary capacity, certainly so far as the whole broad field of knowledge is concerned, even of engineering knowledge. So I have learned to content myself with making a very modest endeavor to keep abreast with one very narrow field of engineering. But let me do my very best and still I will come very far short of perfection in learning even to properly construct and maintain a railroad. I know that I can't become an expert in the other fellow's line and I am really afraid to try. I fear that every time I reach out and grasp a great big idea that belongs in the other fellow's field that, my own head being of such limited capacity, something else equally as valuable to me in my own line of work will run over and spill out of the old vessel.

So, after I have spent such a part of each day as I can in making such headway as I may in my own line of work, I do not wish oftentimes to invade the domain of other engineers. I would rather walk into that wider domain that belongs to the brotherhood of all mankind. I would rather use that time in reading some of the good things stored up by generations of eminent scholars, in wandering in imagination through the interesting Scottish highlands with the great Sir Walter, in watching Miss Maude Adams in Peter Pan, or some such play, or in simply playing ball at home with my little boys. And I know that these things do me far more good.

But before I leave the subject of these engineering lectures I want to tell you of an objection to every one of them, and yet many of these lectures were given by men who command our sincerest regard. But in all these lectures that I heard there was not, if I remember correctly, a single discussion of a moral question. The ideas dominant in every one of them were the Thomas Gradgrind facts as to how the work was done, the results achieved and how much money was gained or saved thereby. Seemingly there was to be no distinction in the future lives of the students, as conceived by these lecturers, between right and wrong. The strenuous life was urged for all it was worth, but no hint was made to these young men at this, the character forming, stage of their existence, of the world's need of their living clean, upright lives filled with beauty, simplicity, repose, and neighborly kindness. Perhaps it was thought that these things were too obvious to mention. But it is in this especial matter that the addresses to students of public men differ from those that we used to hear twenty-five and thirty years ago.

And now let me ask the teachers present if the objections I have pointed out against these engineering lectures cannot with some justice be made to much of the whole training of our engineer students. In our eagerness to fill their heads with a smattering of knowledge of all forms of engineering, or at least of as many as we can possibly crowd into our curricula,—in our eagerness to make of them good craftsmen, playwrights, draftsmen, mechanics, and engineers, are we not forgetting to cultivate that side of their lives which must be developed if they are to become men—real *vires* not mere *homines*? Do we not assume too much in supposing that by directing our attention partly perhaps to their manual dexterity but principally to the growth of their minds that their moral and spiritual welfare will take care of itself?

Now I trust that you will not take me for an old croaker dissatisfied with all of the existing state of affairs. And I don't want you to believe that I have come up here with a bad taste in my mouth, nor that I am suffering from either melancholia or hysteria. On the contrary, I have abundant faith in American youth and in our country's future. And I have really little fault to find with the technic itself of modern engineering training, except perhaps, that we try to use too much of it.

In our modern training for our engineers, as in our modern life, I fear we are going too fast. And in our haste to discard the older forms of training we have shelved, I fear, much that the lives of centuries of distinguished scholars have shown to be of the utmost value. I mean the development of the moral or higher and nobler side of the lives of our students.

Perhaps it is a subject which should not be discussed before such an audience as this, but I feel that I must say that I believe there is in our colleges and universities a great deal of inefficient teaching. We make a teacher's promotion dependent upon his success in research work. And it is beyond dispute that the qualities of mind which befit a man to do research work generally unfit him to do efficient work as a teacher. There is room for a long discussion here, but I will cut it short and only say that there is not a nobler work in this world than that of devoting one's self to the profession of teaching, pure and simple, that of leading out, expanding; and helping to grow, the bodies and minds of the young men of the land, the profession of man building. And it is a pity that we cannot have in our colleges a teacher's standing and promotion determined by his success in doing the thing he is employed to do, and for which he is paid.

The student comes to an engineering college to acquire the forms of thought, of speech, of work, and of action that he is to use in his professional life. If we teach him our subjects about after the manner that a burglar would use in instructing an apprentice, we could not expect to add much to his stock of integrity and refinement. But we might add some other things not quite so desirable. If, on the other hand, we make our instruction savor of manliness, courtesy and uprightness, and we choose to bring into our lectures and recitation rooms occasional instances and examples cal-

*Abstract of a lecture before the Engineering Club of the University of Illinois, Feb. 25, 1909, repeated by request before the Senior Classes in Engineering at the University of Wisconsin, March 29, 1909. A more extended report of the lecture appeared in the Wisconsin Engineer for April, 1909, and will also be published by the University of Illinois.

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culated to exercise the students' sense of justice as well as his finer feelings, I have that faith in the absorptive power of the American student to believe that he will seize and appropriate to his own use a goodly share of those desirable characteristics while they are passing his way. Every teacher who has brought himself close to the lives and aspirations of his students knows and feels this to be true.

And now I want to make some definite charges against the engineering graduate of to-day and to say wherein he impresses me as not being quite the equal of former college men in some of the characteristics of a true and noble man. Please note that though I say I make charges, I do not attempt to prove logically that those charges are correct.

I grant at once, of course, and I am proud of the fact, that the modern engineer graduate is far more helpful than that older man was in advancing the industrial progress of the world. One must be a fool to argue otherwise. But it is difficult to see why, in these modern days when everything else has improved so much, our students should advance in one direction and recede in another. If it be true that there is a recession in some ways, it must be the fault of the student's training and environment, for the American Caucassian youth is the same to-day that he has been for a hundred years. And if he is receding in this respect his teachers should shoulder the responsibility, for, as of old, they can mould to honor or dishonor, even as the potter has power to fashion his clay. The great body of our young graduates is just what their teachers and their mothers have made them.

Let me give you an instance now of the power of the teacher in molding students' morals: I taught for a period of seven years ending in 1898 in the school on the banks of the Mississippi River in Louisiana that was founded before the Civil War with the man who afterwards became Gen. W. T. Sherman at its head. Gen. Sherman as all of you know, was a West Pointer, and he made much of drilling his early students in the need of their observing the same code of honor that he himself had learned to observe at West Point. If you should go to a student in that school and ask him what is the sentiment among his companions on the subject of cribbing, he would stiffen his shoulders and haughtily reply, that any man who is allowed to attend the Louisiana State University must prove himself too much of a gentleman to cheat. And the boast is not a vain one. I taught there seven years and in that time we had one serious case of cribbing. In this case the faculty had no need to issue an edict of suspension. The students took care of that part of the case as soon as guilt was established.

But now I can take you to some northern schools in this same country of ours, very much larger and of very much greater reputation, where if you seek out any thoughtful conscientious student and ask him the same question as to the sentiment of the same subject among his companions he will invariably tell you it is about as bad as it well could be. It is a fact that at some of these schools there is hardly a general examination ever held that a number of students are not punished in one way or another for cribbing.

And now how is the difference in the sentiment on this subject to be accounted for at these schools? Would you say that the southern youth is naturally more honorably inclined than his northern neighbor? I know from personal experience with the youth of both sections that this is not true. I can tell you of a school in the south similar to the one referred to on the banks of the Mississippi River where the student sentiment on this subject is fully as bad as at any northern school.

I tell you the difference is accounted for by the unanimous continuous assertive force of the teachers in the interest of common honesty in the one case, and by the lack of concerted action and moral force on the part of the faculty in the other.

To me this is a painful subject, but I should like to ask this question before I leave it. If we permit our students to form the habit of cribbing and cheating their way through school, what guarantee have we that they will not persevere in the habit after they leave our care and go on cheating and swindling their way through the world? Are there degrees of culpability in the acts of cribbing, cheating, swindling, and stealing? I have never been able to see such a distinction. And yet I don't wish to fight any duels for saying that I believe it is true that a man who cribs his way through school will, as a rule, steal his way through his business life if opportunity offers.

And now I make my first and most serious charge against the engineer graduate of to-day; owing to the fact that the development of his moral nature is somewhat neglected in present-day training, he is apt to be less entirely honest than were the graduates of former days.

I will follow the first charge immediately with the second, and will say that owing to the fact that we crowd our modern engineering courses so full the present-day engineer graduate is liable to be less thorough than the old-time graduate was. Twenty-five years ago, 15 or 16 hours of recitation per week was considered enough. Extraordinary students were sometimes permitted to take 18. Now from 20 to 21 are required and frequently extraordinarily bright students, or those who have conditions to make up, are permitted to take from 25 to 30.

In this connection let me tell you of an experience with modern men. A few years ago a couple of Junior students were secured from the school that claims to be the foremost engineering school in the United States to work one summer on one of the western railroads. These young fellows were specially recommended by their teacher to do the work at which they were put. They worked for three days in a vain attempt to connect two tangents out on an open prairie by a simple three-degree curve. Instead of getting the work done they brought in a demonstration purporting to show that the tangents could not be so connected. The same two men ran a line of levels four miles long several times and never once came within 3 ft. of the true result, nor did any two trials give results within 3 ft. of each other. I should like to give you a lot of individual experiences I have had with new college men where their lack of thoroughness in the very things they were supposed to know best has dearly cost the railway companies employing them and me, and caused the young men to be set back instead of forward in their profession, but time forbids.

My third and last charge is that the present-day graduate, having skimmed so hastily over so many subjects without thoroughly mastering any or all of them, and not having his sense of duty keenly developed, is in some degree wanting in real efficiency, in contentment, fortitude, loyalty, and true manliness.

Perhaps, as President Woodrow Wilson intimates, it is characteristic of American national life to be discontented with one's lot and to be continually striving for something higher and better. But the degree of unrest among the engineer graduates in the positions into which they fall seems to exceed even the national unrest.

It used to be supposed that if a man received a promotion in railway work once in every three or four years, he was doing well, but like the labor union men, if the wages of the average graduate is not increased in railway work three or four times a year he feels sure that the road he is working for doesn't appreciate his eminent services.

I made it a practice while at Madison to ask my boys to write back to me after they had been out of school a while to let me know how they fared. I got together one day 25 such letters that I had received in the previous two or three years and went through them with a special purpose in view. Out of the 25 there were just three that expressed any satisfaction whatever with the work they were doing. Now let me tell you that every single one of those fellows had better positions than could possibly have been hoped for at so early a date in their career if they had graduated 25 years ago.

I sometimes think that our high schools, which are so largely taught by women, and where the number of female students is generally about three to one, are more potent in robbing our young men of real manliness than any other cause. A graduate of an average high school is really a graduate of a female seminary. A recent critic says that the average high school male graduate has learned from his association at school about enough to become a milliner or a dressmaker and that is about all. Look up some of the recent writings and speeches of the leading psychologist in America, Dr. Stanley Hall, and you will be surprised to see what such an authority as he thinks is the effect on our young men of our women-taught high schools. Dr. Hall is quoted as saying that when a mother has brought her son to the age of 14, she ought to untie her apron strings from around him, hand him over to his father and say, "Here is our son, I have had the care of him now for 14 years and have made the best boy out of him that I could. Now it's up to you to take him and make him a man."

This world is full of noble women, and no man has a keener appreciation of womankind, nor a greater respect for a true woman, than I, but I never saw one yet that could impart any manliness to a youth. A fellow must acquire manliness by brushing up hard against men.

Now when we get these women-taught high-school men in college what should we do to rub out the femininity that they have absorbed? If the femininity is well grounded it sticks pretty close. Did you ever notice how diffidently a fellow acts and feels among men who has been so unfortunate as to be raised in a house full of nothing but women and girls? Such are the boys that stand on the side lines and bleachers and scream while the real men of the school are winning the football and baseball games. The poor creatures, they don't know how to yell.

The college needs to teach such students how to be men as well as how to think. And no small part of its duty is to teach them how to fight and how to stand up for one's own. And when I say they need to be taught to fight and to stand up for their own, I, of course, don't mean that they should do this in any brutal or unmanly way. But it is too often the case that young men are discredited because they do not know how to assert themselves in a firm and dignified way that commands attention.

I like authority and I like discipline, and the good old hickory switch for bad boys and something very like unto it for obstreperous young men. There are a few real men developed in this world who have not been well exercised by both—by discipline and authority.

I have long ago gotten the idea out of my head as a teacher that the way to become popular with students was to make things easy for them; in other words, to let them have their own way. The way to win a young man's lasting affection and gratitude is to lead him, or drive him if need be, to develop a power or capacity that he did not know was in him; or, in other words, to bring him to achieve.

I could give you many an instance where young men have failed to accomplish the results expected of them for lack of the qualities named in my third charge above, and yet young graduate engineers who fail as I have indicated often wonder why, in railroad work, brakemen, telegraph operators, section foremen, and station agents, men oftentimes who have not enough education to solve a problem in the rule of three, are promoted ahead of them. The reason is clear to the railroad manager. He knows that while the college man was attending the woman-taught high school, and going to college where he sat up late at night and ruined his health by eating indigestible suppers, and where he listened to easy lectures that appealed to him intellectually only in a dim and distant way, the brakeman and the telegraph operator had been learning by getting down close to sweating humanity the lesson of how to get there. And now when the railroad needed men to get things done, it wanted men who had brushed up hard against other men until they knew how to act like men.

I was talking one day, a year or two ago, to a level-headed, thoughtful, public-spirited and charitable business man who has been connected with the administration of the financial affairs of one of the large schools of the country for a great many years, and I mentioned some of the ideas that I have just related and asked him to what he ascribed these objectionable tendencies in so many of our young men.

He said that he had noticed the same short-comings in the young men with whom he came in contact and that he believed that there was something almost radically wrong with any system of education that did not imbue the graduates of the schools with a higher sense of duty and a greater love of work for its own sake. In effect what he said was:

I believe that the whole trouble is accounted for by the spirit of the teachers in our schools. The students are taught that the chief end of their education is, not to learn to enjoy life and to be useful citizens, but that they must expect to get right up to the top at once in whatever calling they enter; nothing else is worth while. These teachers in industrial and engineering schools study one subject until their minds become warped and they come to think that nothing else besides their own little subject counts. Further, they study the one subject until they become proficient in it, and coming in contact for the most part only with students of immature minds, they unconsciously assume an air of superiority to the rest of mankind. The student unconsciously apes his teacher and after he has passed his examinations comes to believe he, too, has mastered the subjects in his course and become a superior being; he adopts the condescending tone of his teacher and falls heir to his teacher's sense of superiority.

When the student goes into business his employers and associates don't take kindly to the attitude the young man assumes. What they generally want is work and help instead of arrogance and advice. The busy world sits down on the graduate good and hard and the young man becomes despondent and moves away in search of some other position where those eminent abilities of his will be more appreciated.

And now, young gentlemen, I want to say that in these days there are too many engineering graduates for all of you to hope to stand at the tiptop of your profession. It is an old saying that there is room at the top, but as the industrial world is at present organized, the top men must have a good many strong men upholding the platform on which they stand. Take for example, the organization of your great railroad here, the Chicago & Northwestern. It has use for hundreds of young men as track supervisors, bridge supervisors, draftsmen, assistant engineers, signal engineers, clerks, train electricians, roundhouse foremen, road masters, yard masters, train masters, division superintendents, etc. In the next eight years, I doubt not it would be possible for everyone of you young men to get into the service of that great corporation in some such capacity as I have named, where you would have a chance to do some useful work and to earn a decent and honest living. But I wish to remind you of the fact that that road has only one president, one general manager, and one chief engineer. And while I do not wish to discourage you, I doubt very much if it will ever have an urgent need for any one of you in any one of these positions. Even if it does, it will be safe to say that it will be so far in the future that you can't safely count on it now. It will not be until the sap has been pretty well dried out of your youthful bodies, and your minds and bodies have been strengthened by having successfully withstood many a trial and many a hardship.

But I want to say that the great need of the Chicago & Northwestern R. R., and of the industrial world which it typifies, is one of men who will do their work well in ordinary fields. It is a need of a man in each position who can be depended upon, who does not feel the need of the applause of his fellowmen to make him do his best. It is a need of men who are not seeking the spectacular and the heroic, but who are willing to do the same thing over and over again every day of their lives, doing it too with the same thoroughness and conscientiousness that our mothers used when we were boys in regularly washing the dishes three times a day.

But men seldom work that way these days. No sooner does a man become familiar enough with his tasks to be able to do them thoroughly, than he is off again to find something different if not better. Sameness tires him. The modern young man must have his work program changed at least as often as the bill of the vaudeville show that he attends.

In these days we never teach our young men that there is for each man such a thing as finding his own level, and that when that level is found he will make the world better and himself far happier and more useful by adapting his life to it and quietly staying in it.

I have known several men in my life that had found their level and who consistently refused to be led out of it. And I wish I had time to relate to you the happiness that has come to some of them who declined "promotion" for the sake of duty or in order to live a quiet, orderly and useful life. There are many such men who fill up the measure of their existence fully as well as Mr. Roosevelt or Mr. Taft does his.

There are thousands of places in our great industrial country where young men as engineer graduates can easily secure useful work that will make you and the world better for doing it. And this work does not need always to be done at the top of the ladder. I sincerely believe that the greatest kindness I could possibly do to this fine body of young men would be to make each one of you feel that in an engineer's life there is something worth while besides what's at the top, that there are many things in this life better than money, and that for the present the chief concern of each one of you should be to make himself a whole man.

THE LOCATION OF A BRIDGE LEVEL over streams subject to sudden floods is always a matter of extended study backed up by the judgment gained by experience. Those engineers who have been engaged in such work will be interested in the following advice on the subject by an engineer who is familiar with the peculiarities of railway and bridge location in the Spanish-American countries to our South. Although in a humorous vein, there is a deal of solid advice in it.

The writer believes that the best general method to locate heights of important bridges in a tropic district that is being opened to civilization by the building of a railroad under rush orders, is for the bridge engineer or reliable assistants to camp on the banks of the rivers during the *primaveras* and *temporales* of the rainy seasons. Let the engineers get up in the night if necessary to mark the high-water lines during local floods. The bridge engineer should also hold caucus with the local brotherhood of the Universal Society of High Water Liars that one is sure to find among the oldest inhabitants, if inhabitants there be. Take the mean level of the high-water lies, salt it a trifle with what you believe your own first-hand observations have told you, then raise your bridge level three meters above the probable mean you have selected in order that floating tree limbs may not reach up and pull your bridge from its seat. Having thus studied your waterway, for a job where you are working overtime to get ready for the track and steel gangs, you may put in your steel work with prayers that it will stay until it rusts out. If the bridge fails after this, you can look wise and blame it to Providence. The writer has come to this belief after having assisted at the obsequies of several tropic bridges that were located by engineers of unquestioned good judgment and international reputation. As a matter of fact, nearly all tropic, inland, mountain-fed streams, unless they are bound by deep cañons, overflow their banks, so it can be usually accepted as axiomatic that the steel should be well above the banks, even where the banks rise 50 or 60 ft. above the normal water level.

The Susquehanna River as a Source of Power.*

By MASON D. PRATT,† M. Am. Soc. C. E.

The Harrisburg City Water Works, under the able management of Mr. Edmund Mather, has made among other interesting records a complete daily reading of the gage height of the Susquehanna River at that point since the summer of 1890. The U. S. Geological Survey has also made gagings of the river at that point and in its Hydrographic Progress Report No. 20 for 1892 published a rating table for the volumetric discharge of the river. We thus have at this writing a complete history of the flow of the Susquehanna River for over 18 years. Both of these sources of information may be considered reliable. The writer in his leisure moments has made some studies of these data and the hydrographs which have resulted from these studies he trusts will be found of interest. The purpose of this paper is mainly to point out some of the limitations of the Susquehanna as a source of power.

The main trunk of the river at its junction of the north and west branches at Sunbury has an elevation of 450 ft. above sea level. The distance from this point to its entrance to the Chesapeake Bay at Havre de Grace is 121 miles, thus giving an average gradient of 3.7 ft. per mile. The elevation of low water mark at the Harrisburg Water Works from which their gagings are taken is 289.4 and the average gradient from this point to the mouth is 4.35 ft. per mile. Fig. 1 shows the profile of the river between these points.

The numerous rapids below Harrisburg taken in connection with the larger discharge due to increasing area of water shed and attractive sites for dams has claimed the attention of engineers and others interested in water power developments. There is already constructed and in operation a hydro-electric plant at York Haven, sixteen miles below Harrisburg, having a nominal head of 25 ft., and there is another now under construction at McCall Ferry, 43 miles below Harrisburg, to have a nominal head of 53 ft. Other plants are contemplated and there is already in operation a very complete and well built plant at Warrior's Ridge on the Juniata, a few miles above Huntingdon. This latter plant is interesting in that it has a steam auxiliary.

The fact that the gradient of the river is low and that there are no perpendicular drops at any point precludes the possibility of any other than low head developments, that is from 20 to 80 ft. The average gage height of the river is about 3½ ft., corresponding to a discharge of 30,000 cu. ft. per sec. and this fact on first blush would lead one to think that a comparatively large capacity plant would be warranted.

On Fig. 2 is given the monthly average rainfall for the years 1895 to 1906. These averages are taken from the records of twelve observing stations on the Susquehanna drainage area, viz.: Oswego, Cooperstown, Binghamton, Elmira and Cortland in New York State, and Wilkes-Barre, Williamsport, Selingsgrove, Lockhaven, Lewisburg and Harrisburg, in Pennsylvania, so that the curve may be considered a fairly accurate average of the rainfall on the watershed. The river discharge curve is of course the average from the records at Harrisburg. The effect on the run-off of melting snow by the spring rains in March is very noticeable. It is also interesting to note that while the average rainfall is on the increase in the summer months, the discharge is on the decrease, due to the effect of evaporation and renewal of ground water storage, while in the fall the ground water having been replenished and the foliage disappearing, the river discharge increases.

The result of combining the daily gage readings of the river with the rating figures is given in Fig. 3, which is the average run-off curve for the last 18 years. The actual run-off for the maximum year 1903 and the minimum year 1895 are also shown. From this rating curve it can be shown that we have the following expectations:

30,000 sec.-ft. run-off, 165 days or 45% of the time.
20,000 sec.-ft. run-off, 225 days or 62% of the time.
10,000 sec.-ft. run-off, 315 days or 86% of the time.

The maximum and minimum years, however, show wide variations from these figures. This diagram and others which will be presented later show how disappointing in final results is the use of average figures as a basis for hydro-electric power developments. For instance, the shaded section of this diagram shows the time in which a development requiring 10,000 sec.-ft. may be expected to "deliver the goods" and it might seem that a storage of 5,000 sec.-ft. for 25 days would take care of the deficit. This question of storage will be taken up later. Average run-off curves are interesting but not of great value.

In the next hydrograph, Fig. 4, is shown what may be called "characteristic curves" for low water periods which in four out of the 18 years extend over a period of 100 to 136 days. These curves represent a summation of the river discharge. 1895 was the banner year for long-continued drought and it will be noted in this year the river had an average discharge for 50 consecutive days of 3,700 sec.-ft. 1900, however, had the lower average discharge of 3,150 sec.-ft., but for only 35 days. A moderate amount of storage would take care of the difference between these two years. 1908 has a curve which would lie between those for 1899 and 1895, but the writer did not wish further to complicate the diagram with it. From the table printed below the diagram it will be noted that in only two years of the 18 did the river fail to go below the 2-ft. stage, while in the other 16 it stood at or below the 1-ft. mark for a period of from 9 to 40 days.

It is apparent from this hydrograph that we will have to modify our views in regard to depending on a 10,000 sec.-ft. discharge to that corresponding to at most a 1-ft. stage or 6,900 sec.-ft., depending on a little matter of storage to tide us over the years like 1895 and 1900.

It might seem at first glance from this hydrograph that it would be entirely safe to figure on a uniform flow of 4,400 sec.-ft. or that corresponding to a 0.5-ft. stage. That this is not the case will be seen by drawing lines parallel to this 4,400 sec.-ft. line and tangent to the characteristic curve at the high points F. The space beyond the tangent point between the tangent and the curve (shaded for 1900) represents deficiency for which storage must be provided.

When the discharge is above the average the surplus water is flowing over the dam and as soon as the river discharge falls below this rate the storage must be drawn on; and as the storage decreases the available head decreases and the volume of water required to produce the same power increases. The plant operator without a sufficient storage capacity soon finds that he has available only the actual flow of the river on a reduced head, therefore it will be no uncommon occurrence for the plant to find itself actually out of business.

These low stage "characteristic curves" are the most important features to be discovered in connection with a low head hydro-electric power development, where reliability and constant output are essential; and an engineer in making plans for such a plant without having long-time accurate records of his source of supply will be groping in the dark.

Turning now to the hydrograph in Fig. 5, which shows the continuous record of the low stage run-off for the dry years 1895, 1899 and 1900; this diagram probably illustrates a little more clearly the effects of fluctuation in discharge on a plant obligated to deliver a certain minimum amount of power and the necessity of storage when this minimum is above the low stage run-off.

It is evident from what we have seen that any plant along the river, no matter how great its capacity in

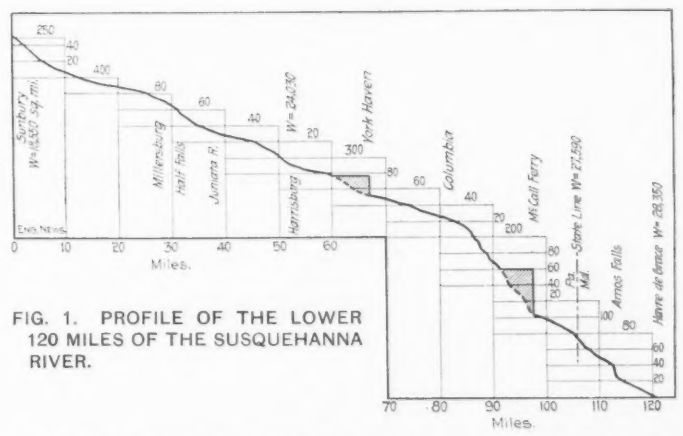

FIG. 1. PROFILE OF THE LOWER 120 MILES OF THE SUSQUEHANNA RIVER.

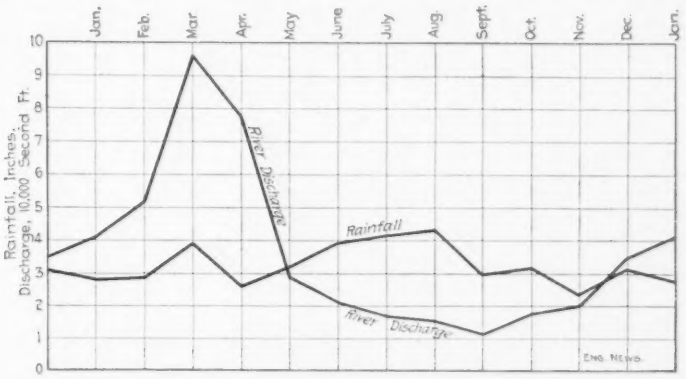

FIG. 2. RAINFALL AND RIVER DISCHARGE, SUSQUEHANNA RIVER, 12 YEAR AVERAGE, 1895-1906.

*Paper presented before the Engineers' Club of Central Pennsylvania, April 16, 1909.

†Engineer, 16 South Market Square, Harrisburg, Pa.

installed apparatus but without ample storage, will frequently and for long periods be able to deliver only that power resulting from the actual discharge of the river passing through the available head of its dam. The study of the characteristic curves will show that this available power is greatly below that resulting from the average discharge of the river. A consumer of power from such a source as this requiring a constant supply such as electric railways and lighting companies, will therefore have to be protected by an auxiliary steam

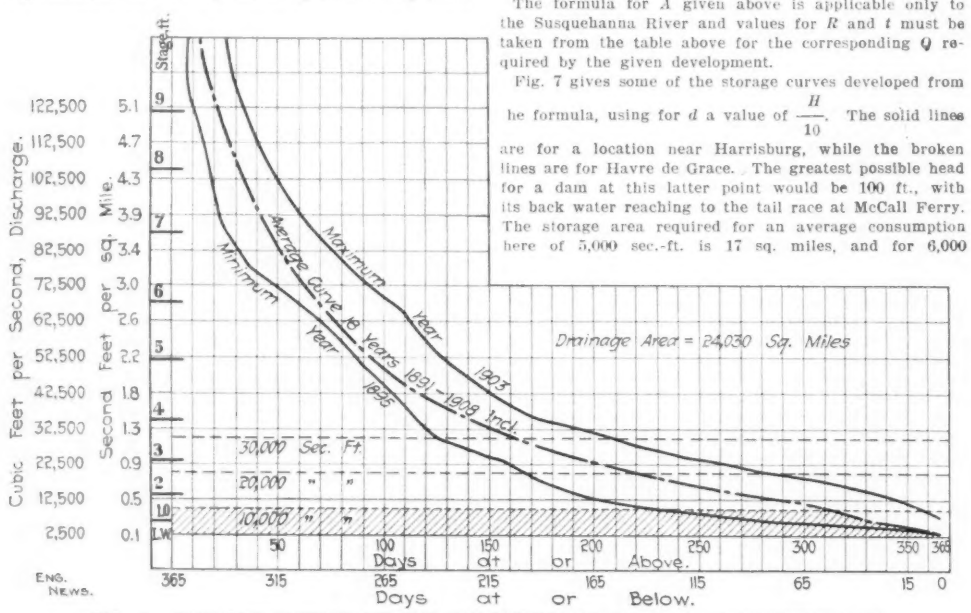

FIG. 3. RUN-OFF CURVES OF THE SUSQUEHANNA RIVER AT HARRISBURG, PA.

plant, which, owing to the other tribulations inherent in the operation of a hydro-electric plant and the transmission of its power over long distances, should be of ample capacity to take the entire load of the consumer. The installation and maintenance of such a plant, which must be in constant operative condition, becomes a very serious charge and requires very careful analysis in order to determine what price shall be paid for hydro-electric power in order to effect any economy.

The diagram in Fig. 6 shows the HP. resulting from any given head and discharge in both water HP. and commercial HP. This latter is given as 56% of the water or theoretical HP. This percentage will vary with the character of distribution. The introduction of frequency changers or similar apparatus will reduce it still further. Nor has the power used for exciters been taken into account; this is considerable, so that we probably would be nearer the mark in assuming 50% instead of 56%.

In order to increase the capacity of the hydro-electric plant at times of low water, the question of storage capacity is one of vital importance and in order to determine the storage required under any given conditions, the writer has developed the following formula:

Let A = Storage area required in square miles.
Q = Average quantity of water in cu. ft. per sec. required by given plant for minimum output.
H = Head available.
t = Time in days of low water during which storage would be drawn on.
R = Average run-off in cu. ft. per sec. during the time t.
d = Allowable drop in feet of pond surface.
W = Water shed in square miles.

A run-off of 1 cu. ft. per sec. will cover 0.0031 sq. miles one ft. deep in 24 hours.

Then: $(Q - R)\ t$ = quantity of water to be stored, which must, however, be increased by that amount required to give the same power as the available head decreases through the allowable drop d, as follows:

$$\frac{(Q-R)\ t}{1-\frac{d}{2H}}$$

Since the run-off figures are given in the table below for Harrisburg where the watershed area is 24,030 sq. miles:

(1) $R' = \frac{R}{24{,}030}\ W$ for any location along the main track where it is safe to assume the discharge proportional to the watershed.

The complete formula then becomes:

(2) $$A = \frac{0.0031\ t}{d} \times \frac{Q - \frac{R\ W}{24{,}030}}{1-\frac{d}{2H}}.$$

An inspection of the run-off diagram, Fig. 5, gives the following values of R and t for varying values of Q.

Q	R (at Harrisburg).	t (days).
10,000 sec.-ft.	5,150 sec.-ft.	138 in 1895
9,000 " "	5,060 " "	136 " "
8,000 " "	4,920 " "	132 " "
7,000 " "	4,640 " "	120 " "
6,000 " "	4,230 " "	72 " "
5,000 " "	3,100 " "	38 in 1900
4,000 " "	2,800 " "	32 " "
3,000 " "	2,660 " "	25 " "

The formula for A given above is applicable only to the Susquehanna River and values for R and t must be taken from the table above for the corresponding Q required by the given development.

Fig. 7 gives some of the storage curves developed from he formula, using for d a value of $\frac{H}{10}$. The solid lines are for a location near Harrisburg, while the broken lines are for Havre de Grace. The greatest possible head for a dam at this latter point would be 100 ft., with its back water reaching to the tail race at McCall Ferry. The storage area required for an average consumption here of 5,000 sec.-ft. is 17 sq. miles, and for 6,000 sec.-ft. 23.4 sq. miles. The actual area flooded by such a dam as shown by the U. S. Geological Survey map is 21 sq. miles. The plant would therefore have a minimum capacity of about 5,500 sec.-ft., which from the diagram in Fig. 6 corresponds to 34,000 commercial HP. The construction of such a dam at Havre de Grace would involve the relocation of 30 or 40 miles of steam railway and several small town sites.

The plant at McCall Ferry has 53-ft. head and about 7 sq. miles pondage. Fig. 7 shows it could depend on a little over 3,000 sec.-ft., corresponding to 10,000 commercial HP. The plant will have 135,000 HP. of turbines, and will be able to deliver 75% of its capacity, or 50,000 commercial HP. an average of 250 days in the year, or less than 70% of the time, and its full capacity a little more than half the time.

Comparative Costs of Operating Steam Plants With and Without Hydro-Electric Auxiliary Power.

The gist of all this is that while the Susquehanna River has available for considerable periods enormous power-producing capacity, on the other hand there are frequent and long-continued periods when this capacity is reduced to a comparatively small fraction of its average and at such time the power consumer must be supplied with power from some other source. This is particularly true of electric railways and lighting companies whose power requirements are continuous the year around and in whose case it is very essential that there be no interruptions in the supply of power. This outside or standby source of power should have a capacity equal to the total requirements of the consumer for there are frequent interruptions to the supply of power from a hydro-electric plant at a distance, due to many other causes which I have not mentioned. This standby plant may be either in connection with the hydro-electric plant as at Warrior's Ridge, or it may be the existing power plant of the consumer, as is more frequently the case.

When a railroad or lighting company is approached with a proposition from a hydro-electric plant the first question generally taken up is the commercial one, and a railroad company, with power costing, say, 1 ct. per KW.-hr., is offered hydro-electric power at ¾-ct., the proposition looks tempting at first glance. There are several things to consider, however. In the first place hydro-electric power is generally offered as high tension, alternating current. This must be transformed into low potential direct current and this transformation loss in two plants to the writer's personal knowledge is from 25% to 30%. To effect this transformation the necessary static and rotary transformers must be installed, interest and depreciation on which investment must be taken into account. Then, as stated above, the original steam plant must be maintained in operative condition and experience has shown that it is necessary to have steam on continuously as emergencies come suddenly and often without warning, so that the only real saving in the steam plant is a certain percentage of the fuel with possibly a slight reduction in the amount of labor, lubricants and other minor charges.

An interesting analysis of an actual case of this kind is given below from the writer's experience:

COST OF STEAM PLANT.	Per. KW.
(a) Permanent: Ground, Foundations, Buildings, Wiring, Water Supply, Coal Bunker, Incidentals, Engineering and Superintendence.	$35.00
(b) Boilers, Boiler setting, Piping, Pumps, Condensers, Heaters, Coal and Ash Handling Apparatus, Smoke Stack and Flues, Economizers	55.00
(c) Engines, Cranes	30.00
(d) Generators, Switchboard and other elec. app.	30.00
Total cost per KW. installed	$150.00

COST OF OPERATION IN ELEC. RY. STEAM PLANT.

These are actual figures made by a plant built by the writer and are the results from a full year's operation as shown by the books of the owner:

	Cts. per KW.-hr. on Switch B.
Wages	0.1610
Fuel	0.3080
Water	0.0197
Oil and waste	0.0141
Maintenance of boiler plant	0.0210
Maintenance of electric plant	0.0065
Sundry supplies	0.0117
Total	0.5420 cts.

Interest and Depreciation Charges:		
5%	Interest on total cost of plant....	150 × .05 = $7.50
3%	Depreciation on Item (a).....	35 × .03 = 1.05
10%	Depreciation on Item (b).....	55 × .10 = 5.50
7.5%	Depreciation on Items (c) and (d).	60 × .075 = 4.50
		$18.55

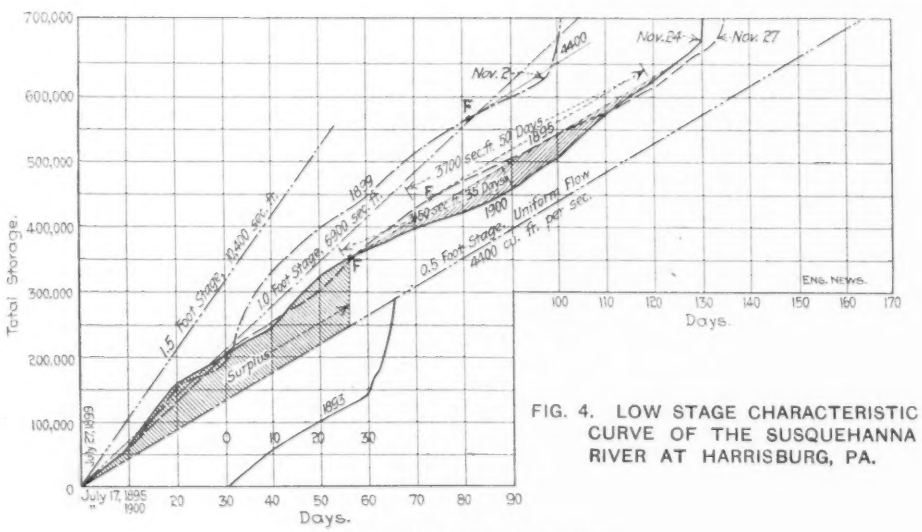

FIG. 4. LOW STAGE CHARACTERISTIC CURVE OF THE SUSQUEHANNA RIVER AT HARRISBURG, PA.

18 YEARS' RECORD OF LOW WATER.

1891	Lowest stage, 2.0 ft.	1900	See curve
1892	Between 0.5 and 1.0 ft. 30 days	1901	Lowest stage 1:0
1893	Between 0.3 and 1.0 ft. 30 days	1902	Below 1.0 ft. 9 days
1894	Between 0.2 and 1.0 ft. 23 days	1903	Lowest stage 1.0 ft.
1895	See curve	1904	Lowest stage 1.0 ft.
1896	Between 0.2 and 1.0 ft. 32 days	1905	Lowest stage 2.1 ft.
1897	Between 0.5 and 1.0 ft. 40 days	1906	Lowest stage 1.0 ft.
1898	Between 0.6 and 1.0 ft. 30 days	1907	Below 1.0 ft. 12 days
1899	See curve	1908	Between 0.5 and 1.0 ft. 136 days

This should be multiplied by total KW. capacity of plant and divided by total annual output in KW.-hrs., which in the case of the plant mentioned would be:

$$\frac{18.55 \times 2{,}000}{8{,}000{,}000 \times 100} = .4640$$

Total cost of steam power 1.0060 cts.

COST WITH HYDRO-ELECTRIC POWER.

Static and rotary transformers would have to be installed to convert the high tension alternating current furnished by the hydro-electric plant to 600 volt d. c. together with necessary switchboard at a cost of .....$37.50 per KW.

(No charge is made for housing or floor space.)

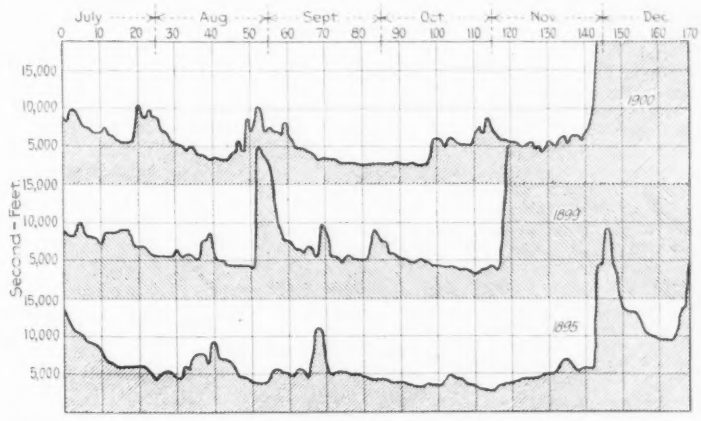

FIG. 5. LOW STAGE RUN-OFF CURVES OF THE SUSQUEHANNA RIVER AT HARRISBURG, PA.

The cost of operation then becomes:

Wages, reduced one-half.....	0.0805 cts.
Fuel, reduced 90%—the remaining 10% being required to maintain steam plant in operative condition and to operate it in short periods	0.0308
Water reduced 90%.....	0.0020
Oil and waste, 75%.....	0.0035
Maintenance ½	0.0137
Sundries ½	0.0058
Int. and Dep'n* on steam plant...	0.4640
	.6003 cts.

To this should be added interest and depreciation on new apparatus, at 5 + 7.5 = 12.5%, as follows:

$$\frac{37.50 \times .125 \times 2{,}000}{8{,}000{,}000} = .1172 \text{ cts.}$$

.7175 cts.

Cost for all steam operation.....1.0060 cts.

Difference ..... .2885

Owing to the 25% loss in transformation as shown in the case of two plants in the writer's knowledge this difference must be decreased in proportion, and we have:

$$\frac{.2885}{1.33} = 0.216 \text{ Cents}$$

As the highest price that could be paid under the given conditions, without any profit on the transaction.

From which it is seen that the railway company could not afford to pay much over two mills for hydro-electric power in place of the 7½ mills assumed. The operating costs in the steam plant mentioned are possibly exceptionally low, but the figures are actual and not estimates or test runs, and there is no reason why they cannot be duplicated in other properly designed and well operated plants.

In the case of a lighting company the conditions are somewhat different as on account of usually poorer load curve the KW. cost is apt to be higher, while, on the other hand, a considerable percentage of the hydro-electric power can be turned directly into its system through static transformation whose efficiency is high. The loss however in transforming the current for arc lighting purposes will correspond more nearly with those of electric railway losses. The lighting plant would therefore probably be justified in paying a somewhat higher price for hydro-electric power.

The above remarks apply to usual cases where a consumer already has a power plant of his own. In the case of a consumer of hydro-electric power building a stand by plant with the original intention of using hydro-electric power, such a plant of course would receive altogether different treatment and its design would differ radically from usual types of power plants. In such a plant the use of gas or oil engines would be attractive for the reason that fuel could be stored without the losses incident to banking fires in the case of steam plants, and where the gas storage capacity is sufficient to operate the plant for short periods not exceeding a few hours, the item of wages would be materially reduced. Experience has shown that the majority of interruptions in hydro-electric power service are of short duration.

The investment in a hydro-electric plant is in nearly all cases greater than in first-class steam plants, and in some cases several times greater, in which case the fixed charge from interest alone on the excess cost is apt to approach and may even exceed the cost for fuel in a steam plant.

These and other causes make investments in hydro-electric plants elusive. This is particularly true along such a river as the Susquehanna. Such plants, however, would become much more attractive investments if there were located in their immediate vicinity industrial plants of such a nature that power could be utilized when it was available and which would suffer no great inconvenience or loss from shut downs in periods of low water or other troubles. A hydro-electric plant could then deliver a much larger volume of current and without the enormous line and transformation losses incident to long distance transmission. Hydro-electric power developments will also become more attractive when some more efficient means of storing large quantities of power for long periods of time are discovered than are at present known. Hydro-electric power developments should have most careful and thorough engineering investigation before launching, particularly is this true from the fact that local conditions affecting the final result vary so greatly that seldom are two alike.

*The depreciation of a steam plant is practically the same whether idle or in operation.

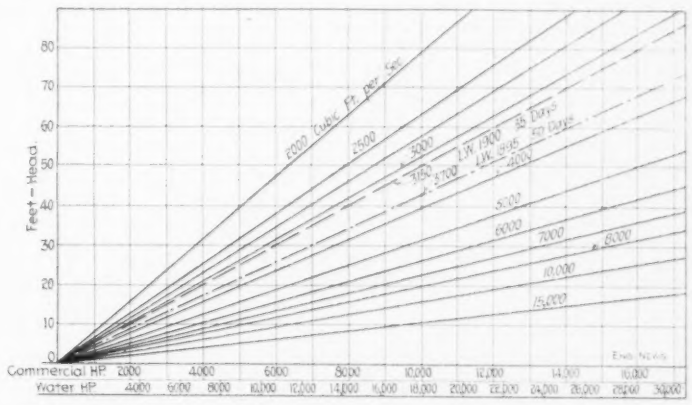

FIG. 6. DIAGRAM SHOWING HORSEPOWER RESULTING FROM GIVEN HEADS AND DISCHARGES.

Note.—Commercial HP. is that deliverable to customers at a distance and equals the product of the efficiencies of the generators and transmissions.

Turbines	80% Effy.
Electric generators.....	93% "
Transformers	97% "
Transmission	92% "
Transformers	97% "
Secondary transmission	90% "
Total efficiency	56%

The Hydro-Electric Plant of the McCall Ferry Power Co.

[We submitted the above article to Mr. Cary T. Hutchinson, Chief Engineer, McCall Ferry Power Co., for any comment that he might care to make, and received from him the following answer.—Ed. Eng. News.]

Sir: The article by Mr. Mason D. Pratt under the caption "The Susquehanna River as a Source of Power," calls for some comment from me inasmuch as it seems to show a want of accurate knowledge regarding engineering data of this company's plant at McCall Ferry on the Susquehanna River.

The statistics given for the discharge of the Susquehanna River are substantially correct; as the article states, the minimum flow of the Susquehanna River at McCall Ferry is approximately 3,000 sec.-ft., within the limits of error of stream measurements. I adopted this figure for the minimum discharge six or seven years ago, when I first became interested in the matter, and I have seen no reason since that time to change it. The plans of this company and the design of its works are based on a minimum flow of 3,000 cu. ft. per sec.

The rated capacity of the plant is 75,000 KW., at a 50% load factor, at the low pressure bus-bars of the substations in Baltimore or elsewhere; the greater part of this power will be sold in large blocks,—that is, the company will be a wholesaler and not a retailer of power. The efficiency of the plant from the water to the substation bus-bars will be 66.5% and not 50% as estimated by Mr. Pratt; this figure is based on the guaranteed efficiencies of the various pieces of apparatus already ordered and takes into account the exciter losses as well as the power required for substation lighting and other uses. The dam will form an equalizing reservoir of a large capacity, and will enable the plant to deliver its rated capacity of 75,000 KW. at any load factor, as long as the stream flow is equal to or greater than that required for the average daily load; that is, to deliver 75,000 KW. at a load factor of 50% will require a stream flow corresponding to an average load of 37,500 KW. The industrial conditions in the territory tributary to the plant are such as to make it certain that the load factor of the load on the plant will not exceed 50%. A delivery of 75,000 KW. at this load factor at a 53-ft. head and 66.5% efficiency requires only 12,500 sec.-ft.

Mr. Pratt discusses the amount of storage required to supplement the low water discharges of the stream. A very brief consideration will, however, show that the reservoir capacity is so great as to make such a proposition entirely impracticable. As a matter of fact, for the year 1905 it would require a reservoir of approximately 350 square miles in area with a usable depth of 10 ft. to maintain the discharge of the river at McCall Ferry, at 12,500 sec.-ft.

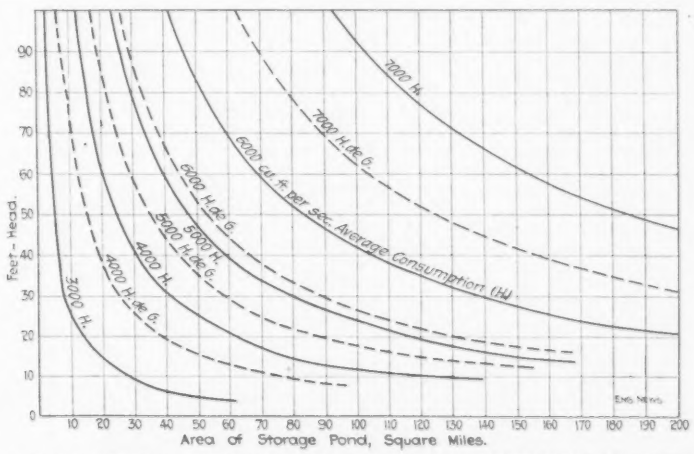

FIG. 7. CURVES SHOWING STORAGE PONDS NECESSARY FOR GIVEN CONSUMPTION ON SUSQUEHANNA RIVER.

(Solid lines = Harrisburg, Pa.; dotted lines = Havre-de-Grace, Md.)

The pond formed by the dam has, however, a large value as an equalizing reservoir; the water contained in the upper 5 ft. is equivalent to 400,000-KW. hours delivered at the substation bus-bars; that is to say, by drawing down the pond level 5 ft., 400,000-KW. hours may be taken out, in addition to that provided by the stream flow. It can readily be seen then that the plant is never deficient in *power*; it can on all days deliver its rated *power*. It is, however, at times deficient in *energy*; the plant will at the lowest stage of the river be able to deliver 75,000 KW. for three hours (2.88 hours to be exact) or 37,500 KW. for six hours. In other words, it can deliver on the worst day 24% of its rated capacity. The fact that the plant is never deficient in *power* reduces the size of steam plant required to maintain the rated output to approximately one-half (should such a steam plant be built) and enables the company always to guarantee its *power* at peak-load hours.

The conditions in the territory tributary to the lower part of the Susquehanna River are such that the erection of a steam plant by the company is not required; there are already in operation several large steam plants, working at a load factor of 50% or less. These plants therefore could develop twice their present energy output without any increase in the capacity of the installed machinery, provided they had a customer ready to take this energy at such times as it might be available. On account of the large (daily) storage capacity of the reservoir formed by the dam at McCall Ferry, this plant can readily take such surplus steam energy during non-peak hours and therefore conserve the daily flow of the river during the low-water hours for use during the peak-hours, when the steam plants will require all their capacity for their own load.

Therefore, Mr. Pratt's paragraph reading—

> The plant at McCall Ferry has a 53-ft. head and about 7 sq. mi. of pondage. Fig. 7 shows that it could depend on a little over 3,000 sec.-ft. corresponding to 10,000 commercial HP. The plant will have 135,000 HP. of turbines, and will be able to deliver 75% of its capacity or 50,000 commercial HP., an average of 250 days of the year, or less than 70% of the time, and its full rated capacity a little more than half the time,

should read—

> The plant at McCall Ferry has a 53-ft. head and about 3.75 sq. mi. of pondage. It can depend on a little over 3,000 sec.-ft., corresponding to 24,000 commercial HP. The plant will have 135,000 HP. of turbines and will be able to deliver from the stream flow alone, 75% of its capacity, or 75,000 commercial HP. on an average of 311 days in the year, equivalent to 85% of the time, and its full capacity 285 days in the year, equivalent to 78% of the time.

The principal reason for this large difference in the statements of the capacity of the plant lies in the assumption by Mr. Pratt of a unity load factor. Another difference is in the low efficiencies that he assumes.

Mr. Pratt deduces a figure at which power must be sold in order to compete with the steam plant; it is not necessary for me to comment on this part of his paper inasmuch as it applies to all hydro-electric plants—not to the Susquehanna alone. It is based on the assumption that a steam plant of full capacity must be kept ready at all times for instant use. No hydro-electric plant would be built on such a basis, and the many contracts for power in force made by managers

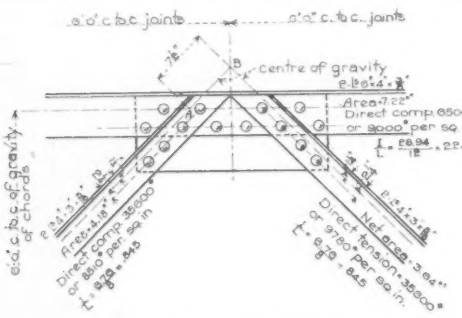

Fig. 1. Sample of Eccentric Joint in a Truss, Producing Bending Stresses Greater Than the Direct Stresses.

of railway and lighting companies shows clearly that such is not the practice.

In the state of New York there is a total capacity of approximately 850,000 HP. in water-power; of this amount only 15% is provided with auxiliary steam or gas power.

It should also be noted that the comparison should be made between hydro-electric power delivered as alternating current at the bus-bars and not converted to direct current, on account of the fact that generation by direct current is practically obsolete in all except small plants. Furthermore, it is frequently possible for the hydro-electric plant to deliver its power to the substations of the railway company, and therefore its cost should be compared with the cost of generation and of transmission to the substations.

It is implied by Mr. Pratt that the McCall Ferry plant is, so to speak, "over-powered"; that is to say, that an excessive amount of machinery has been installed for the conditions of the river. This, I think, is not a fact; indeed, the plant is designed on very much the same ratios as exist in other plants of the same character. For instance, the ratio of capacity of machinery to the power of the river at the lowest known discharge of the McCall Ferry plant is approximately 8.3. This ratio for the plant of the Hudson River Power Co., at Spiers Falls, is approximately 7.5, and at the plant of the Connecticut River Power Co. on the Connecticut River it is approximatley 12. Moreover, the amount of auxiliary steam energy that must be supplied to maintain the rated output of the McCall Ferry plant compares favorably with either of the other plants. For the McCall Ferry plant in the average year it is necessary to supply 8% of the rated output by steam. For the Connecticut River plant the amount is 12% when the plant is equipped with only 12,500 KW. and operates at 50% load factor, and will be greater than 20% when fully equipped. The McCall Ferry plant is then designed on lines at least as conservative as those of the other two.

These comparisons could be continued with substantially the same results, but these two instances are probably sufficient to prove that the design of this plant falls into line with that of similar plants in other parts of the country.

Cary T. Hutchinson,
Chief Engineer, McCall Ferry Power Co.
60 Wall St., New York City, May 27, 1909.

Some Faulty Details in Structural Steel-Work.*

By E. W. PITTMAN.†

Attention will be directed to some of the more common faults and inconsistencies that are of frequent occurrence in structural details, and an effort made to illustrate their effects upon the strength of the structures.

Fig. 1 shows a joint in the top chord of a Warren truss. The makeup and properties of the several members are marked in the figure. Taking *A* as center of moments we have for the total bending moment due to eccentricity $35,600 \times 7.5 = 267,000$ in.-lbs. Apportioning this between the four members meeting at the joint according to their values of $I \div l$ it is found that each chord section resists a bending moment of 97,000 in.-lbs. and each web member resists a bending moment of 36,500 in.-lbs. The extreme fiber stress, *f*, which these bending moments induce in the members is:

$$\text{For chords, } f = \frac{M\,y}{I} = 14{,}400 \text{ lbs. per sq. in.}$$

$$\text{For web members, } f = \frac{M\,y}{I} = 14{,}850 \text{ lbs. per sq. in.}$$

Thus it is seen that the secondary stresses due to eccentric connection are 1½ times as great as the primary stresses, which alone were considered in proportioning the members.

Another condition which tends still further to increase the secondary stresses in the web members is the eccentricity of the rivet lines to the gravity axes of the members. This eccentricity is 1 in., as marked, and the resulting bending moment is 35,600 in.-lbs.‡ The general equation for extreme fiber stress for compression member with fixed ends, is

$$f = \frac{M\,y}{I - \frac{P\,l^2}{32\,E}} = \frac{35{,}600 \times 2.75}{6.76 - \frac{35{,}600 \times 9{,}216}{896{,}000{,}000}} = 15{,}320 \text{ lbs. per sq. in.}$$

Particular attention is directed to this result, because this eccentricity of rivet line to gravity axis is a fault of very common occurrence in all types of riveted structures. Where angles are used to resist direct stress, and connected through one leg only, the gage line for the rivets should be set in as close to the back of the angle, or as near to the center of gravity axis as possible. This matter is of fundamental importance, and yet it is habitually disregarded in detailing work.

It is customary to use so-called "standard gages" for angles, pitching the rivets from the back of the angle a distance somewhat greater than the half width of the leg. The rivet clearance for machine driving is shown in Fig. 2. In the case of the web members just discussed, the dimension *A* would be 15/16 in. Adding to this the thickness of the outstanding leg, we obtain 1¼ ins. as the permissible gage of these angles. This coincides exactly with the gravity axis of the angles, and if the rivets were so placed, the extra stress would be entirely eliminated.

Rivets in eccentric connections are sometimes subjected to secondary stresses very much in excess of what they are designed to resist. A good illustration of this is afforded by standard connections for beams§ Fig. 3 shows the standard connection for a 10-in. 25-lb. I-beam. The Manufacturers' Hand Books give 9½ ft. as the minimum span length for which this connection may safely be used with a beam loaded to its full capacity. From the table of safe loads, we find that a 10-in. 25-lb. section 9½ ft. long will sustain a uniform load of 13.72 tons, giving an end reaction of 13,720 lbs., as shown in Fig. 3. This end reaction may be replaced by an equal force parallel thereto and passing through the center of gravity of the rivet cluster, and a couple with a moment $M = 13{,}720$ lbs. $\times$ 3.25 ins. $= 56{,}290$ in.-lbs.

Each rivet in the cluster is subjected to a direct stress $\frac{1}{3} \times 13{,}720 = 4{,}573$ lbs., and a stress due to bending moment. The stress in any rivet due to bending moment varies directly as its distance from the center of gravity of the cluster, and its resisting moment varies as the square of this distance. Calling *a* the stress in a rivet due to bending at a unit's distance from the center of gravity, we have the equation:

$$M = a\,(d_1^2 + d_2^2 + d_3^2), \text{ or } a = \frac{M}{d_1^2 + d_2^2 + d_3^2} = \frac{56{,}290}{6{,}513} = 8{,}650 \text{ lbs.}$$

Now the stress in each rivet due to bending is equal to this figure multiplied by the distance of the rivet from the center of gravity:

$S_1 = 8{,}650 \times 1.46 = 12{,}640$ lbs.,
$S_2 = 8{,}650 \times 1.46 = 12{,}640$ lbs.,
$S_3 = 8{,}650 \times 1.5 = 12{,}980$ lbs.

These forces are drawn in the figure, and combined with the forces $S = 4{,}573$ lbs. The resultant stress on rivets 1 and 2 is 15,600 lbs., as shown.

The web thickness of a 10-in. 25-lb. I-beam is 0.31 in. The bearing area of a ¾-in. rivet is, therefore, $0.31 \times 0.75 = 0.2325$ sq. in., and

$$15{,}600 \text{ lbs.} \div 0.2325 = 62{,}100 \text{ lbs. per sq. in.}$$

is the bearing stress on web of beam. That this is excessive can hardly be denied. Let us hope that in the next issue of the Manufacturers' Hand Books, this table giving minimum span length for which standard connections may safely be used will be revised.

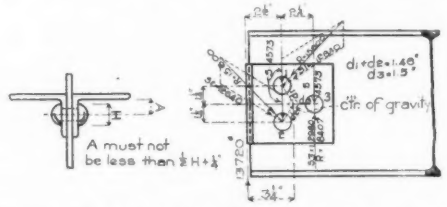

Fig. 2. Data for Minimum Rivet-Gage in Angles, to Minimize Eccentricity of Rivet-Line.

Fig. 3. True Rivet-Stresses in Standard Fitting for 10-in. I-beam.
(For minimum length of 9½ ft.; no friction considered.)

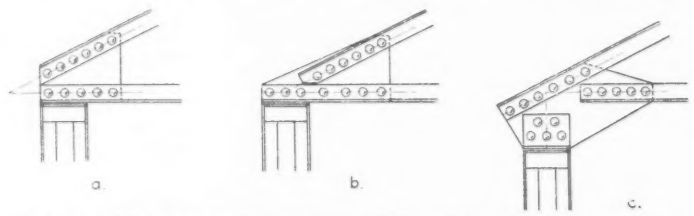

FIG. 4. BAD AND GOOD DETAILS FOR HEEL OF ROOF TRUSS.

Fig. 4a shows the heel of a roof truss. This detail has been made familiar by its wide use, and yet the fault is pronounced. The three forces acting as the heel, namely the compression in the rafter, the tension in the bottom chord, and the column or wall reaction, are non-concurrent. A bending moment results which induces large fiber-stresses in the members. This detail is susceptible of the same analysis as the eccentric joint of the Warren truss.

Fig. 4b likewise is an improper detail, unless the heel-plate is thick enough to resist the shearing forces between the point of intersection of the three forces and its attachment to the members. The plate should also be planed or chipped flush with the backs of the angles of the bottom chord when it is not possible to get sufficient rivets immediately over the column to transmit the total reaction into the plate. Fig. 4c shows an efficient and proper detail for the heel of a roof truss.

The practice of using ¼-in. and 5/16-in. gusset plates in roof trusses is very common, yet considerations of economy as well as efficiency would seem to dictate the use of thick plates. The plates should be of such thickness that the bearing value of a rivet in the plate is about equal to the value of the rivet in double shear.

*Extracts from a paper entitled "Secondary Stresses in Framed Structures," read before the Engineers' Society of Western Pennsylvania, Jan. 5, 1909, and printed in its "Proceedings" for February, 1909.

†Chief Engineer, Pittsburgh Steel Construction Co., Pittsburg, Pa.

‡In discussing the paper Mr. H. S. Prichard showed that the bending moment due to such eccentricity would ordinarily amount to but one rivet-load multiplied by the eccentricity, or in this case, 8,900 in.-lbs. This would give a fiber stress of $\frac{8{,}900}{6.76 \div 1\frac{1}{4}} = 1{,}650$ lbs. compression or $\frac{8{,}900}{6.76 \div 2\frac{3}{4}} = 3{,}620$ lbs. tension, making the total extreme fiber stresses 8,510 + 1,650 = 10,160 lbs. per sq. in. compression and 9,780 + 3,620 = 13,400 lbs. per sq. in. tension, respectively.—Ed.

§On this subject see experiments described in Eng. News, 1895, I—318; 1898, II—43,203.—Ed.

This would reduce the number of rivets at a joint by nearly one-half, and reduce the size of the plate correspondingly. Whatever slight increase in weight the thicker plates entail is more than compensated by the reduction in rivets. The use of smaller plates and fewer rivets also measurably reduces the secondary bending stresses in the members due to fixity of their ends. This is quite an advantage, and would justify the use of thick plates aside from any other consideration.

Fig. 5a shows the detail of a kneebrace connection to a column, which is not uncommon in mill-building construction. This detail is open to the same criticism as the other eccentric connections already discussed. It

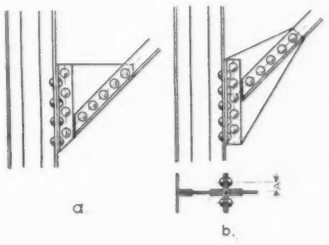

Fig. 5. Common Detail for foot of Kneebrace, and Corrected Detail.

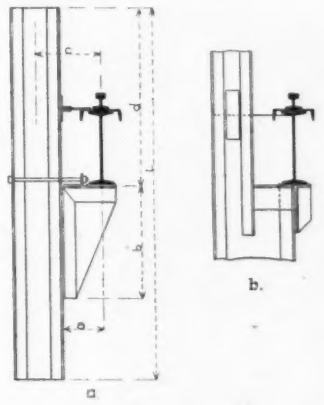

Fig. 6. Two Methods of Supporting Crane Runs.

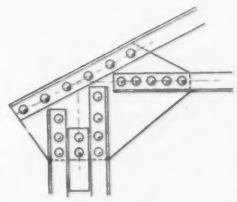

Fig. 7. Connection of Truss to Column Using Gusset-Plate as Kneebrace.
(Bad arrangement.)

is especially to be condemned in view of the fact that the kneebrace is subject to tension as well as compression, and when the kneebrace is in tension the entire stress must be resisted by two rivet-heads. Fig. 5b shows the proper detail for this connection. The gage, *A*, for the rivets connecting the knee to the column flange should be as small as possible, and the thickness of the connection angles should be such that their moment of resistance at the rivets is equal to the bending moment. This bending moment is equal to one-half the horizontal component of the stress in the kneebrace multiplied by *A*.

Fig. 6a shows the detail of a bracket for the support of a crane runway girder. As usually detailed, this type of support has a dangerous weakness, and it has come to be regarded with distrust. When the bracket is correctly detailed, however, and all forces properly provided for, it affords an economical and efficient support for light crane runway girders. Through bolts should be used at the top of the bracket capable of resisting a stress equal to $\frac{P\,a}{b}$.

The load *P* being eccentric to the axis of the column, bending moments are induced, but in the case of light cranes these are usually much less than the bending moment at the foot of the kneebrace due to wind load, and the bracket attachment requires only a small increase in the moment of resistance of the column. Herein lies the economy of the bracket support over the direct column support, as shown in Fig 6b. The metal in the wide web plate below the crane seat takes the crane reaction and relieves the bending moments in column due to this reaction, but it does not measurably increase the moment of resistance of the column at the point of maximum bending moment; that is, at the foot of the kneebrace.

This leads to a consideration of what is, perhaps, the most common fault in mill-buildings with kneebraced bents, and that is the inefficiency of the column at the foot of the kneebrace. In a very large proportion of mill-buildings as ordinarily constructed, the column above the crane seat is made from 6 to 10 ins. wide, regardless of theoretical requirements, and in most cases the columns are insufficient to resist the bending moments due to the wind load for which the building purports to have been designed. Most specifications for mill-buildings that are regarded as standard require that the structure be designed to withstand a wind pressure of 20 to 40 lbs. per vertical square foot. Nevertheless it is probable that half the kneebraced mill-buildings standing to-day would actually collapse under a wind pressure of 10 or 15 lbs. per sq. ft. In view of this fact, an assumed wind pressure in excess of 20 lbs. may well be regarded as absurd.

If the columns and kneebraces of a mill-building about 60 ft. wide with 20-ft. bays and 40 ft. high to the chord were properly proportioned to resist a wind pressure of 30 lbs. per sq. ft., the result would be startling. The columns at the foot of the kneebrace would be from 20 to 24 ins. deep, and the kneebrace, chords and main web members of the truss would be correspondingly massive.

Purchasers of mill-buildings seem to derive some satisfaction in specifying high wind pressures, but they usually seem satisfied to accept the design submitted by the lowest bidder. It is hardly necessary to add that this design is made in utter disregard of the specifications. While a designer is, perhaps, justified in disregarding absurd requirements in specifications, there is certainly no justification for many, if not most, of the designs for high mill-buildings.

This stricture applies with particular force to such construction as is shown in Fig. 7. This construction is sometimes used, in lieu of a kneebrace, in order to economize headroom and to avoid obstructing the crane trolley travel. This is a gross and flagrant fault. The knuckle-plate should never be used as a substitute for the kneebrace in a building high enough for a crane.

Kneebraces at best are not very efficient, and they should be resorted to only when there is no better method of bracing a building to withstand the horizontal wind pressure. When a building is of indefinite length, or subject to future extension, kneebraces are necessary, as each bent must be self-sustaining and transmit all of its portion of the wind load to the foundations direct.

In the case of a building of fixed length, however, it is generally more economical to make the bottom-chord lateral system a horizontal truss to transmit the wind loads to the gable ends of the building, and thence through diagonal bracing to the foundations. In this case the eave struts are the chords of the horizontal truss, and they should be made stiff enough to act as compression members, unsupported for the panel length.

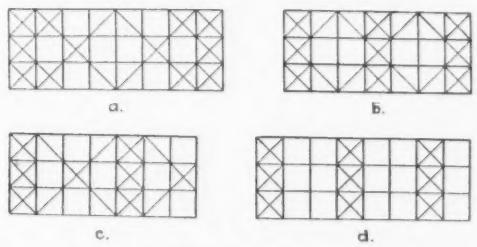

Fig. 8. Continuous and Discontinuous Bottom-Chord Bracing in a Mill-Building.

Fig. 8a shows a bottom-chord lateral system suited to this condition. In all cases, whether kneebraces are used or not, the bottom-chord lateral bracing should be made continuous in order to insure good alinement for the columns. This is very important, especially where traveling cranes are used.

Figs. 8b and 8c show two systems of continuous bottom-chord bracing, either of which will serve the purpose of alining the tops of the columns, and therefore the crane runways.

Fig 8d shows discontinuous bottom-chord lateral bracing which is not uncommon. Nevertheless it is a glaring fault, and should be avoided even in the cheapest buildings without cranes.

A few years ago there came under my observation a building with discontinuous bottom-chord bracing where high-speed heavy cranes were in use. Acute trouble developed in the use of the cranes due to bad alinement of the runways. Operation of the cranes was suspended for a few days, and the master mechanic of the plant undertook to correct the trouble by rectifying the alinement of the rails. This was done with a transit, and new holes were drilled in the flanges of the runway girders where necessary, and the rails clamped in place. On completion of the work all rails were straight from end to end of building, and no further trouble was anticipated. Operations were resumed, and at the end of a few days there was a recurrence of the same old trouble. It was discovered that the rails were as badly out of line as ever. The master mechanic was nonplused, and in his uncertainty he was overwhelmed with suggestions from interested employees. Some suggested reinforcing the columns below the crane seat, and some suggested tearing down the building and its total reconstruction. Sane advice finally prevailed, however, and the trouble was permanently cured by the simple expedient of making the bottom-chord bracing continuous throughout. The rails and clips were replaced in their former position, and the building was pulled into line and held there by means of nuts and turnbuckles on the bottom-chord lateral rods.

In a building of indefinite length, the function of the bottom-chord bracing is simply to prevent the lateral movement of adjacent bents relative to each other, and to reduce the unsupported length of the bottom chords of the trusses. This second function is important because in kneebraced buildings the bottom chord is subjected to compression stresses due to wind action, sometimes in excess of the deadload tension stresses, and it must therefore be designed as a strut as well as a tie.

Of late there has been a marked tendency toward heavy construction in mill buildings. This is manifested in the many new specifications in which low unit-stresses are specified, and in which it is provided that no metal of a less thickness than $^5/_{16}$-in. or $^3/_8$-in. shall be used in the structure. Of course, this provision is designed to procure a stronger and more stable structure, but it fails wofully in its purpose. It serves only to concentrate metal and weight in parts of the structure where it does absolutely no good. The use of high unit-stresses, and the use of ¼-in., or even $^5/_{16}$-in. metal is not undesirable if the building is scientifically designed and all details intelligently worked out. The destruction of mill-buildings by corrosion is not nearly so rapid as the destructive action of racking forces due to insufficient bracing and faulty details. Unless all the various forces that may act on a building are considered and proper provision made for their resistance, the building will rapidly deteriorate, and soon rack itself to pieces, however low we take our unit-stresses, and however thick we make our metal.

A New Valve Gear for Locomotives.

The Stephenson or link motion valve-gear for locomotives was used exclusively in this country until a few years ago, when the Walschaerts valve gear (largely used in Europe) began to be introduced. A special advantage of the latter gear is the reduction in weight for engines of large size, and this is one reason for the large extent to which the Walschaerts gear has been adopted within recent years. While the Stephenson gear is still used on the great majority of American locomotives, and the Walschaerts gear ranks second, other types of locomotive valve gear have come into use to a certain extent. Some of these were described in our issue of May 4, 1905. Within the past two years there has been introduced the Baker-Pilliod valve gear, which has been applied (or is being applied) to some 35 or 40 engines of different classes on several railways. The Chicago & Alton Ry. has 20 engines equipped with this gear, and we are informed by Mr. P. Maher, Superintendent of Motive Power and Equipment, that while no elaborate tests have yet been made the gear is giving entirely satisfactory service.

In the Baker-Pilliod gear the motion is derived mainly from a return-crank on the main crank-pin, with an auxiliary motion from the cross-head. In this respect there is a similarity to the Walschaerts gear, but the throw of the return-crank is less than in the latter, and is uniformly 6½ ins. for all lengths of valve travel up to 6 ins. The mechanism is supported from a cast-steel cradle or beam outside the wheels, having one end bolted to the guide yoke and the other to a cross brace extending across the main frames. The general appearance of the gear as applied to a consolidation (2-8-0) engine of the Chicago & Alton Ry. is shown in Fig. 1

The arrangement and operation of this new gear is shown in Fig. 2, which represents its application to an engine of the Atlantic (4-4-2) type. There are no sliding links or blocks, but all the parts have pin connections. There are three fixed points, as indicated on the drawing. The so-called eccentric rod (A) has its rear end attached to the return-crank, while its forward

end is suspended by an arm (B) from the short arm (C) of a combination lever which revolves on a fixed point. The longer arm (D) of this lever is connected to the crosshead by the rod (E), so that the end of the eccentric rod moves in an elliptical path due to the combined action of the return-crank and the crosshead. The eccentric arm (F) forms an extension of the eccentric rod (A). This arm has a bearing at an intermediate point (G) from which there is a connection to the valve stem. The end of the

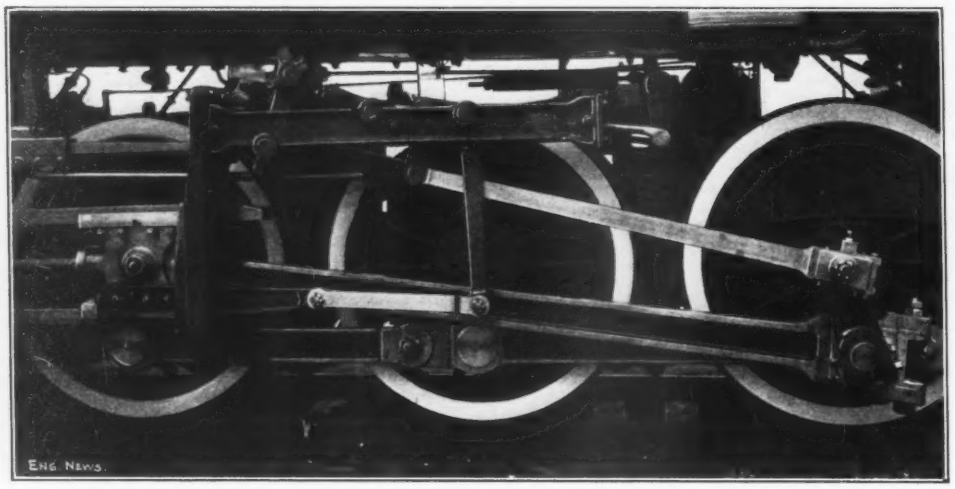

FIG. 1. THE BAKER-PILLIOD VALVE GEAR APPLIED TO A CONSOLIDATION (2-8-0) LOCOMOTIVE OF THE CHICAGO & ALTON RY.
P. Maher, Superintendent of Motive Power and Equipment.

eccentric arm is connected at (H) to a radius arm (I) whose upper end is pivoted at (J) to a rocker (K) swinging on the fixed point (L). The bearing of this fixed point is shown in Fig. 2 as supported by a standard resting on the guide bars. This arrangement is not now used, the bearing being carried in the cradle, as shown in Fig. 1.

To the rocker (K) is attached a rod (M), whose other end is carried by an arm on the reversing shaft. The movement of the reversing lever in the cab, therefore, shifts the position of the point (J) and thus varies the curved path described by the end (H) of the eccentric arm. This arm (F) then has one end (connected to the eccentric rod) traveling in an elliptical path, and the other end swinging in a circular arc about the point (J). The valve is operated from a point (G) whose travel is a combination of the elliptical and circular motion. A short arm (N) connects the point (G) with the bell-crank lever (O-P), which rocks on the third fixed point of the gear, as shown. To the lower arm (P) of this bell-crank is attached the valve rod which operates the rock shaft, from which in turn motion is transmitted to the valve stem and valve. The total weight of the two valve gears on the engine, from the main crank pin to the valve rod and the crosshead connection (and including both cradles), is about 2,500 lbs., of which the moving parts for both sides represent 1,028 lbs. All moving parts are the same for any size or class of engine. As the gear is entirely outside of the driving wheels it is easily accessible. All joints or connections are mechanically positive, there being no links or blocks and no loose sliding or lifting joints. The accompanying table gives a comparison of the performance of two passenger engines on the Toledo, St. Louis & Western Ry. for July, 1908; one of these had the Stephenson valve gear and the other had the Baker-Pilliod valve gear.

Valve gear	Stephenson	Baker-Pilliod
Miles run	4,914	5,587
Passenger car miles	17,286	23,154
Tons of coal consumed	280	256.5
Av. miles per ton	17.5	21.7
Coal per engine-mile, tons	114.4	91.8
Coal per pass.-car-mile, tons	32.3	22.1

The special features claimed for this gear may be enumerated as follows:

(1) Uniform lead at all points of cut-off, and a larger port opening at all points of cut-off than in other valve gears.

(2) Uniform cut-off. Any cut-off from 75% to 85% at full gear can be obtained by lengthening the quadrant so that the lever can be moved lower down. This movement drops the head (J) of the reverse yoke, increasing the travel of the valve and increasing the cut-off at full stroke.

(3) Total absence of pre-admission.

(4) Late release. With cut-off at 25% of the stroke, the release is at 75%. Thus with a 24-in. stroke and 6-in. cut-off, the exhaust port does not open until the piston has traveled 18 ins. It is claimed that with the same stroke and cut-off in the Walschaerts gear, the release is at 65% or when the piston has traveled about 15½ ins.

(5) Late and balanced compression. Excessive compression in the short cut-off is eliminated entirely.

(6) Reduced back pressure, due to the quick complete release.

(7) Lower terminal pressure, permitting the use of a larger exhaust nozzle.

(8) There is no strain on the reversing lever, which can be unlatched and moved under any conditions, with the throttle either open or closed.

(9) The effect of wear does not come directly upon the valve, as in the Stephenson and Walschaerts gears.

(10) A greater range of valve events than any other gear, due to the positive and direct connections in its movement to various positions.

(11) It is specially adapted to high speeds, producing an efficiency equal to that of gears having two or four valves.

(12) The power of the engine is increased by reason of the higher effective and more uniform pressure upon the pistons.

The gear was invented and patented by C. J. Pilliod and A. D. Baker (patent issued Nov. 20, 1908), and is being introduced by the Pilliod Co., 1545 Old Colony Bldg., Chicago.

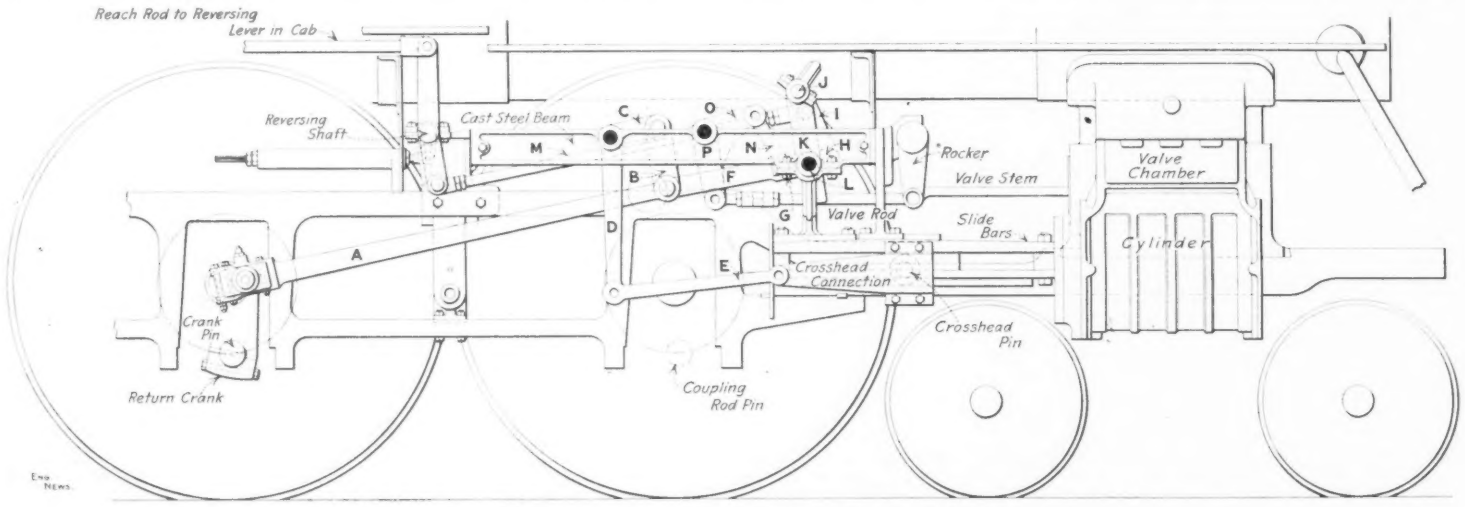

FIG. 2. THE BAKER-PILLIOD VALVE GEAR FOR LOCOMOTIVES.
The Pilliod Company, Chicago, Makers.

THE WORLD'S PIG IRON PRODUCTION, according to a table prepared for "Mineral Industry," showed in 1908 a decrease of 12,476,359 metric tons from that of 1907. The total production in 1908 is given as 48,271,555 metric tons and the percentage of decrease was 20.5%. The decrease in the production of the United States was greater than that of any other country both in tonnage and per cent., being 10,002,869 metric tons or 38.6% of the 1907 production.

TRACK ELEVATION which will involve a double-deck crossing is to be carried out at Grand Crossing, in connection with the Chicago track elevation work. The tracks of the Illinois Central Ry., Pennsylvania Lines, Lake Shore & Michigan Southern Ry. and New York, Chicago & St. Louis Ry. intersect at this point, and when the city required the elevation of the tracks above the street level an endeavor was made to provide for a separation of the railway grades in order to eliminate a complicated and busy grade crossing. Up to the present time, however, the railways have not been able to agree among themselves as to the necessary arrangements. It is reported, however, that negotiations have been completed and that the Pennsylvania Lines and the Lake Shore & Michigan Southern Ry. will elevate their tracks to a height of about 27 ft. above 75th St. so as to cross above the elevated tracks of the Illinois Central Ry. The tracks of the New York, Chicago & St. Louis Ry. will be parallel with and at the same level as the Illinois Central Ry. at the crossing, but will then rise to connect with the Lake Shore & Michigan Southern Ry. at the higher level.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
ATLANTA: Candler Building
RUDOLPH MOSSE, BERLIN AND HAMBURG, GERMANY
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Entered at the New York Post-Office as Second-Class Matter.

A notable international assemblage of engineers is to be held in England next spring. An invitation has been extended by the Institution of Mechanical Engineers of Great Britain to the American Society of Mechanical Engineers to hold a joint meeting in England early in 1910. The Council of the American Society, at its meeting on June 2 voted to accept the invitation. Following the council meeting, the bearer of the invitation, Sir Robert Hadfield, was the guest of honor at a dinner given at the Engineers' Club of New York by members of the Council and the Meetings Committee of the American Society.

Twice before, the American Society of Mechanical Engineers has visited England, in 1899 and again in 1900. The entertainment and the festivities of those meetings are a vivid memory to all those who participated. The date and place of the meeting in 1910 are not yet definitely fixed, but it is probable that Sheffield or Manchester will be chosen and the time selected ought to be not earlier than May, as many engineers who might attend would find it more difficult to leave business in the earlier spring months.

Suppose when the locomotive was first invented that the valve gear applied to it had been some type driven by return cranks and rods from the crosshead instead of by eccentrics. If that had happened and then years afterward some inventor had come along with the Stephenson link driven by eccentrics on the shaft, would he not have had a hard time to get his new device into use? One can imagine how the difficulties with slipped eccentrics and eccentric running hot would have damned the new invention.

Unquestionably the valve gear which bears the distinguished name of Stephenson has points of excellence: and yet we question after all whether it is not ignorance and inertia more than anything else that causes it to be still used on reversing engines more than all other types of valve gear combined.

The Stephenson gear is comparatively simple. Its operation is easily understood. Only a very small proportion of the men engaged in locomotive design and construction are familiar with the intricacies of steam valve gears. Do not these three facts furnish the probable reason why the Stephenson gear continues in use while newer forms of valve motion receive little attention, no matter what their merits?

Again, in considering the merit and demerit of different valve gears a factor very commonly overlooked is the power required to drive the gear. And yet this is far from being unimportant particularly in the case of a large engine. On large marine engines the work imposed upon the valve gear is so heavy that assistant steam cylinders have been applied to reduce the load on the gear. In modern heavy locomotives, the valves are so large that a very considerable amount of power is required to drive them. By way of illustration, on the huge Southern Pacific Mallet articulated locomotives illustrated in our issue of April 29, piston valves 15 ins. in diameter are used.

If it were possible to apply a dynamometer to a valve gear which would indicate on a scale the horsepower absorbed by the gear itself, we fancy some radical changes in steam engine construction might result.

The above thoughts are suggested by the article describing a new locomotive valve gear, published elsewhere in this issue. Whether the new valve is or is not superior on the whole to the Stephenson link, we do not here pretend to say; and in fact data obtained by careful scientific tests are not yet available. But the fact that the new gear dispenses with eccentrics ought alone to be sufficient to secure for it careful attention from engineers engaged in locomotive design.

We have before pointed out that a large part of the saving in fuel consumption on which the advocates of electric locomotives lay such stress can be secured without the enormous investment that electrification requires simply by modernizing the steam locomotive.

A great deal has been said in the public prints about the projected deep waterway from Chicago to the Mississippi River by way of the Chicago Drainage Canal and the Des Plaines and Illinois rivers. It is not generally known that a waterway between Lake Michigan and the Mississippi now exists across the State of Wisconsin; and while it is of shallow draft, its capacity has been recently demonstrated by the passage through it of two river steamers of considerable size.

The route referred to extends from the head of Green Bay on Lake Michigan up the Fox River 38 miles to Lake Winnebago; across Lake Winnebago and through the upper Fox River for 165 miles to the Portage Canal, 2½ miles in length with 9 locks, thence down the Wisconsin River to its junction with the Mississippi near Prairie du Chien.

The two steamers which made the voyage through the waterway, according to the Burlington (Ia.) "Post," were the "Grand" and the "Rapids," stern-wheel boats which were originally in use on the Grand River in Michigan and were sold to operate on the Arkansas River. The steamers made the passage all the way from Grand Rapids to Little Rock under their own power; but it is stated that they had to remove their stern wheels to pass through some of the locks. It is also stated that it had been ten years since a steamer of such size had traversed the lower Wisconsin River and some of the drawbridges had not been opened in that period.

The Mayor of a large city in the central West replied to a letter from our business department as follows:

We have no desire to place any contracts outside of our resident contractors.

You say: "We have proven to hundreds of municipalities that such advertising saves many thousands of dollars on the contract price."

This is one way of putting it, but only from your standpoint. We may save the $2.40 per inch insertion in our City Treasury and take out of our circulation $24,000, which is left with the Local Contractor, which is turned and returned and the Tax Payers, the men who furnish this money still have the original amount in circulation here, as against the $2.40 per saved through you in the City General Fund, for that reason we do not ask any bids upon material or work that can be done by some of our Local Contractors and Tax Payers.

If this is sound reasoning, then the Mayor had better call at once for bids to put a high stone wall all about his city!

It is absurd in these days of universal trade to talk of "keeping money in a city" instead of paying it to outside parties. The only way to keep money in a city would be to place an embargo on its trade, to prevent it from sending money outside to buy groceries and clothing and machinery and building materials. There was an era, hardly a century ago, when every little community was really an independent unit. Local work shops of the hatter, the butcher, the furniture maker, supplied the demands of the communities in which they were located. But production on a large scale, coupled with modern transportation facilities, put an end to that system, and the Constitution of the United States forbids barriers being placed upon the trade of one city or state with another.

What the taxpayers of a city want and are entitled to have is the least expenditure to secure a desired result. They are entitled to be protected from combinations among local contractors, and to that end all public contracts should be open to the widest competition.

But the Mayor is worried lest the money paid to an out-of-town contractor be taken out of the "local circulation." Is there any reason for such worry? Let us see. Take for example, a contract for a $100,000 sewer. The contractor, whether he be a local man or a man from some other city, will buy his materials wherever he can get them cheapest, and the same thing will probably be true of his labor. In either case his workmen will spend a large part of their wages in the city for board and other supplies while the work is going on. Thus, so far as everything but the contractor's profit is concerned, just as much of the money will be spent in the city if an outside man secures the job. As for the contractor's profit, sometimes there isn't any; and sometimes when an exorbitant profit is made by a local contractor, it means that so many thousand dollars have been diverted from the taxpayer's pocket to the contractor's on the plea of patronizing local industry.

A correspondent objects to a statement in an advertisement in a recent issue of Engineering News with reference to the adhesion between steel and concrete. He says the statement is "absolutely ridiculous" and that a high-class engineering paper should not permit such statements to be made in advertisements.

Perhaps; but our correspondent will recall that even the learned societies in their published transactions print a formal announcement that "the Society is not responsible for the statements made in the papers read before it." With that standard before us, the idea that *advertisements* should all be critically scanned to see whether they convey "the truth, the whole truth and nothing but the truth," appears like a "counsel of perfection."

The most any journal can attempt to do is to see that the advertisements which it publishes contain nothing of a libelous nature or nothing regarding a competitor passing beyond what may be considered fair competition. Of course, also, fraudulent and irresponsible advertisers are excluded by all properly conducted journals. Aside from these limitations, the advertiser who buys space may talk sense or nonsense and propound truths or fallacies as he pleases.

The great majority of advertisers in a journal of the standing of Engineering News undoubtedly appreciate the fact that enlightened self-interest as well as a good conscience will be best served by sticking closely to the truth and to sound and well-established engineering facts and principles in their published statements. But we cannot establish a censorship over the advertisement writers to prevent any of them stretching the truth beyond the elastic limit. Infallible censors for such a job are not available, in the first place; and even if they were, we think their employment would relieve the advertiser from a part of the responsibility which it is his business to carry.

The Proposed New Building Code for New York City.

The present Building Code of New York City is confessedly defective and out of date in many respects. There has long been need that the code should be revised and made to harmonize with modern methods of construction.

Two years ago, after several unsuccessful attempts, a revision of the New York code was authorized and the work was placed in the hands of a Commission. Now the framing of a Building Code is a task calling for expert ability of a high order. It demands intimate practical knowledge of what is good practice in every branch of building construction. It calls for sound judgment to decide how and where restrictions should be introduced. One might well suppose that for the framing of such a code the best experts available in the architectural and engineering profession would be brought together and entrusted with the task of drafting the new code.

That is the ideal. The fact is that this Commission was chosen by the Board of Aldermen and the names of those appointed to serve upon it were as follows:

Thos. J. Brady, Chairman; E. R. Knowles, Patrick F. Kenny, Joseph D. Duffy, Andrew P. Eagan, Patrick J. Reville, John Seaton, Daniel Callahan, P. J. Byrnes, C. B. Meyers, John D. Moore, Edw. S. Murphy, Wm. P. Kenneally, Washington Hull, Charles H. Cullen, Paul Starrett, Jas. C. McGuire, Clarence Lacey, Edw. F. Croker, C. G. Smith, R. S. Doull.

Now the question on which the public has a right to be informed is, what were the qualifications of these men for the task they undertook? In what way did they acquire competence to pass upon the details of concrete construction, or of painting or of heating apparatus? And this question is not one of mere local interest to New York City. It is, unfortunately, the case that the Building Code of New York City, be it good or bad, is copied and quoted and used as a model in smaller cities throughout the country. It is assumed, naturally enough, that New York, as the greatest and wealthiest American city, will insist in its building ordinance on the highest class of construction and that what is good enough for New York can safely be adopted in any other American city.

It is not alone of local interest, therefore, to print the names of those who have framed this new code. We cannot, of course, attempt here to show that these gentlemen are ignorant of engineering and building and architecture. It is proverbially difficult to prove a negative. And it strikes us that the burden of proof is on the other side. What evidence is there that these men as a whole had expert knowledge of the subject with which they dealt? What evidence is there that they were possessed of such high professional standing as would give the public confidence that their work was done in good faith and honestly? What assurance has the public that the code is framed for public protection and not as a club with which one trade interest may defeat a competitor?

We are by no means asserting that all the men on the Commission were incompetent. Some of the members undoubtedly possessed special knowledge and experience which was valuable for the work in hand, Superintendent of Building Brady and Fire Chief Croker, for example. Yet even these men will hardly rank with the high-class engineering talent which should properly be entrusted with the forming of a building code.

So much for the competence (or incompetence) of the Commission. Let us see now what it has produced. On May 13 the Commission submitted its proposed code to the Board of Aldermen in the form of Majority and Minority reports. Each branch of the Commission submitted a separate code. We promptly disavow intention of printing this code in Engineering News. The Majority report occupies nearly 20 closely printed pages of small type in the "City Record." The code offered by the Minority occupies 28 pages. The matter would fill two or three entire numbers of Engineering News, and any of our readers desiring the full text of the reports will have to obtain the "City Record" (the official publication of New York City) for May 20.

To attempt even to criticise in detail the substance of these codes is beyond the limits of our space. What we do desire to record is that a perfect avalanche of protests against the adoption of this code, particularly the one framed by the majority of the Commission, poured down upon the Board of Aldermen and these protests were reinforced by the statements made at a public hearing held last week. Many of the men who submitted these protests are business men, architects and engineers of highest standing and with far wider reputation for expert knowledge of building—to put it very mildly—than the members of the Commission which drafted the code.

It is now up to the Board of Aldermen whether it shall adopt either of these two codes against all these protests or shall refer the whole matter back to the Commission for further revision, or shall do what it ought to have done in the first place, employ a small body of high class and really competent experts to frame such a building code as the City of New York ought to have. It is a pity to say it, but we know of no likelihood that the last-named alternative will be chosen.

And the lesson from all this? Why, the lesson is the old one that the public must learn the absolute necessity of employing able and honest experts to carry on its technical work if it would have economical and efficient government.

The adoption of the proposed new code means to the people of New York more costly buildings, higher rents, and danger to life from fire and conflagration. It means a perpetuation of opportunities for graft. It means the injury of many lines of business for the benefit of competitors. It means trouble for architects and engineers and builders. It means another difficulty placed in the way of securing good government and an opportunity for the honest business man in this seething, struggling mass of humanity which we call New York.

In this criticism, it should be understood, we are referring to the code as a whole and not to any specific feature. We by no means say the code is wholly bad. Some of its requirements are certainly an improvement on the present code, and we have no doubt that some of the members of the Commission did hard and conscientious work in framing the new code. But all this cannot save it from condemnation; and to any city proposing to copy any part of this new code—should New York have the great misfortune to have it forced upon the citizens by the Board of Aldermen—we proffer the advice: Don't.

LETTERS TO THE EDITOR.

Concerning Coated or Painted Reinforcing Rods in Concrete.

Sir: The consensus of opinion, in general as well as in the discussion by your periodical, seems to be that painting the metal in reinforced concrete would enhance the future safety of the structure, provided its original strength is sufficient.

The exception made with respect to grillage-beams of foundations (Eng. News, May 13, 1909, p. 524), in the general arguments against painting, shows that the editor would advocate painting if no harm would result with regard to strength. This example is not the best that the editor could have selected. As long as painting decreases the adhesion, such a grillage-foundation with painted metal will be weaker than without paint, because the carrying capacity of the surrounding concrete is engaged to a smaller extent. A better example is the writer's system to secure crackless reinforced concrete by means of anchor-plates at ends of rods and an initial tensile strain given to each rod from the start. In this case the adhesion is not relied upon at all, and, whatever coating may prove superior for preservation against electrolytic or other attack, its existence and application will in no way interfere with the strength of the structure as long as preserved.

Very respectfully,
Charles R. Steiner.

P. O. Box 214, Gridley, Cal., May 18, 1909.

The Mechanical Removal of Plows from Electric Cars.

Sir: In your issue of April 29 (p. 473), you speak of the possibility of raising and lowering the plows on the cars of the conduit electric railways of Washington without having a man in the pit.

This is being done regularly on some of the lines in Paris, which are managed by an American, Mr. Connet. The car is stopped over a pit, then a sliding plate is moved back by a lever at the side of the track, leaving a wide opening in the street surface under the car. Then an attendant attaches a handle to a shaft on the car and thus winds up a chain which pulls up the plow. The latter is left attached to the car while on its trip along the overhead wire section.

In Berlin a folding plow is used, on the very short conduit section in that city. It can be lowered through the ordinary permanent slot, by chains running to a hand wheel on the motorman's platform. It requires no special attendant, and is often lowered without completely stopping the car.

Yours respectfully,
Francis B. Forbes.

8 West 56th St., New York City, May 3, 1909.

[Since the publication of the editorial noted above, we have learned that in one of the pits in Washington an automatic plow-remover is in use. We hope to give details of the device in the near future.—Ed.]

Strength of Cement Briquettes Stored in Air.

Sir: Concerning the letter of Mr. R. P. Davis in your issue of May 27, 1909, p. 581, discussing the "Strength of Cement Briquettes Stored in Air," I wish to recall that you published Jan. 7, 1904, p. 24, a summary of similar tests made in the laboratory of Washington University six years ago. This summary involved about 800 tests and the results are, in general, similar to those mentioned by Mr. Davis. I suppose the lesson to be learned from them is that strict adherence ought to be given to the observance of standard methods, as specified.

Very truly yours,
J. L. Van Ornum,
Professor of Civil Engineering, Washington University.

St. Louis, Mo., May 31, 1909.

The Technical League Again.

Sir: The writer begs leave to differ with the statement that organizations along the line of the Technical League must be assigned to the labor union class. These organizations are composed primarily of technical school graduates and in this respect differ radically from labor unions. It is true, as you state, that the engineering profession differs largely from other professions in that engineers are almost entirely employed by others. This being the case, it is even more essential that they be organized for their mutual advancement than in the other professions.

In this respect the engineering profession resembles a skilled trade; and organization, which has proved so beneficial to all skilled trades, must necessarily be of great benefit to engineers as well. It is practicable to have an organization which will give all the advantages to be obtained by working together for a common interest, and yet not introduce the objections raised against the limitations of labor unions. Plans are now being developed which it is hoped will give all the benefits of organization, and be free from the objections urged against it.

It is probable that one of the plans followed when this movement attains sufficient size (and from present indications it will reach this condition in the near future), that the members of these organizations will be divided into grades, by examinations taking into account a man's age, experience, schooling, and ability. Such examinations may be conducted along well established lines, and a minimum salary commensurate with the character of the position and local conditions can then be readily fixed. An organization of this kind would not tend to place all men on the same plane; neither would it produce a lower grade of engineer, nor would it prevent members from rising above the level of their associates. Furthermore, an organization of this kind would be of great value to employers.

As regards the societies and other professions, such as the American Institute of Architects, and the medical as well as the bar associations, their activities are not limited to the work of reading and discussing technical papers, or lauding one another's virtues, as appears to be the tendency in many engineering societies. The above organizations have taken an active interest in everything that pertains to the public welfare, and the economic interests of their members. They have been active in furthering a great deal of legislation that has proved not only of value to the community, but to their members financially and socially.

In this respect the present engineering societies have

proved a failure, whereas the opportunity open to them for pushing legislation of benefit to the engineering profession, as well as the public, has been very large. There is no reason why it should be beneath the dignity of engineers to further such legislation as would be to their interest, and we do not look with any disrespect upon the activities of the architect, doctor, lawyer, or minister, when they endeavor to advance their interest by appearing before legislators, and the fact that engineers do not do so is not a mark of distinction, but rather a reflection on their lack of judgment and foresight.

Respectfully yours,

F. Lawrence.

144½ East Ave., Long Island City, May 22, 1909.

Surface Retardation in Open Channels Not Due to Air Resistance.

Sir: May I be allowed to reply to a criticism by Mr. W. Holbrook in your issue of May 6 of the conclusions reached in my monograph on surface retardation in a stream flowing through an open channel?

Mr. Holbrook's contention that the surface velocity is retarded by the friction of the air is at once negatived by the fact, shown by a very large number of observers, that the maximum velocity is found to be below the surface even with a downstream wind of greater velocity than that of the stream. Further, since the state of affairs outlined in the monograph was found to exist in channels having linear dimensions in the ratio of 100 to 1, there would appear to be every reason to justify the assumption that it also holds in much larger channels than those examined, the largest of which was 36 ft. wide.

Yours truly,

A. H. Gibson.

The University, Manchester, England, May 24, 1909.

A Derailment from Rail Expansion.

Sir: In Engineering News of May 6 is an article on "Publicity for Railway Accidents," by W. L. Park, and editorial comments thereon. The writer was one of the "dramatis personae" in a railway accident which occurred eight months ago, and which was attended by features of such peculiarity that a description of the occurrence may be of interest to your readers.

The accident occurred on a branch of the Yazoo & Mississippi Valley R. R. in Mississippi, on Sept. 14, 1908. The train had a day run from Jackson, Miss., to Clarksdale, in the same state, and return, a distance each way of 154 miles. The train was made up of two baggage and express cars and four passenger coaches. The last coach was a "parlor car," and immediately ahead of it was the "ladies' coach." The train at the time of the derailment was 2½ miles from the Clarksdale terminus and running at a speed of about 40 miles an hour, being 15 minutes behind time and running to make a connection. The track was practically level, on a tangent and had only earth ballast. The hour was 1:30 p. m., and the maximum normal temperature for the day was 97° in the shade, as recorded in Clarksdale.

The circumstances of the wreck as observed by the writer at the time were as follows: A companion and myself were seated on the forward seat of the ladies' coach and were engrossed in the discussion of an engineering problem, while examining a map. There came a sudden and violent jolt, which was only momentary, and the train continued to run smoothly with unslackened speed. My companion remarked that we must have struck something; I supposed that the train had struck an unusually heavy animal, from the violence of the jolt, but considered it a closed incident and dismissed the matter from my mind.

After an appreciable interval of time, my seat mate glanced back and uttered an excited exclamation. I also glanced back and saw the hindmost coach turning over and carrying ours with it progressively from the hind end. In a second or two the coach I was in went over with a crash, detaching itself from the one ahead. The engine and forward cars ran on several hundred feet before being stopped.

The chair car (in the rear) had seven passengers, three of whom, ladies, were badly mangled, falling through the large open windows, two being killed outright and the third dying soon after having been taken out of the wreck. The ladies' coach (ahead) was pretty well filled with people, about 20 of whom were more or less severely injured.

The conditions which caused the derailment were most peculiar. A limited extent of track, where derailment occurred, had been jacked up during the forenoon by the track hands, and new cross-ties had been inserted and tamped with the earth ballast. The hold of the track on the roadbed was thereby loosened. The rails had been originally laid too close at the joints, and were at this juncture subjected to high atmospheric temperature. There was also a suggestion of "creeping" of the rails due to a preponderance of heavy traffic in one direction.

The rails were under heavy stress from suppressed expansion, so to speak, which, while they were in true alinement, was taken up by the rails themselves. The oscillation of the tracks disturbed the alinement of the rails at a certain point, and the compression found release by a sudden lateral movement of the whole track, cross-ties and rails, for a short length of track, perhaps less than a rail length. The lateral movement exceeded 2 ft. and made a kink in the rails.

The forward truck of the rear coach left the rails, the rear truck remaining on, and the train continued to run without perceptible slackening of speed for nearly 600 ft., crossing a small trestle. Then the derailed truck reached a part of the track which had not been renewed, and as the ties were rotten the coach was overturned, carrying over the next one ahead. The conductor was caught in the derailed coach, and in attempting to release the brakes was thrown to the floor. The engine driver was not apprised of any trouble with his train until the coaches went over.

The rear coach was dragged on its side for perhaps half its length before coming to a stop, which caused the mutilation of the three ladies that were killed. Before the rails could be got back into alinement, between 3 and 4 ins. of steel had to be cut out of each rail.

Respectfully,

T. G. Dabney, M. Am. Soc. C. E.

Clarksdale, Miss., May 20, 1909.

Construction Records of the Carolina, Clinchfield & Ohio Ry.

Sir: Below you will find a brief report on the progress of construction on a portion of the Carolina, Clinchfield & Ohio Ry., between Bostic, N. C., and Spartanburg, S. C. The work was described in Engineering News, Jan. 21, 1909, p. 53.

The first two miles are covered by J. Nuckols, operating one 70-ton, one 60-ton and one 20-ton steam shovel. The next six miles are covered by Messrs. Purcell, Allen, Sheahan & Co., who have installed two 60 and one 20-ton shovel. They have sub-let a portion of the lighter work to Steele Bros., who have a scraper outfit of 15 teams.

All of the shovels are making excellent progress, considering the peculiar circumstances under which they have been working. The record of Purcell, Allen, Sheahan & Co.'s 60-ton, located at Floyds Creek, is worthy of special mention. During the month of March, this shovel moved 37,000 cu. yds. in a very wet cut. The quantity of water encountered in this particular cut may be imagined from the fact that the dinkey track required corduroying, with two layers of poles, for its entire length of 1,200 ft. on each lift. It is almost past belief, that a shovel could accomplish such a record in this class of material, but such is the case, not only for a single month, but this same shovel moved 35,000 cu. yds. in January and 25,000 cu. yds. in February, making a total of 97,000 cu. yds. for three winter months. This organization is deserving of much praise, for its hustling ability and the desire to take advantage of the least opportunity of increasing the output.

Mr. J. J. Sheahan, of the firm, is on the work all the time and much of the success of the outfit may be attributed to his knowledge of railroad construction, and kind treatment of his employees.

As a comparative cost per cu. yd. to the contractor for this shovel during the month of March, I give actual figures as obtained from the company:

MARCH ESTIMATE, 37,000 CU. YDS.
(Working Days, 24.)

Labor	$2,076.27
Coal	480.00
Supplies	25.00
Repairs	95.00
Oil waste	50.00
Depreciation	170.00
Total	$2,896.27
Cost per cu. yd.	.08
Plus trestle	.01
Total	.09

Distribution.

Loading	.028
Hauling	.018
Dumping	.019
Trestle	.010
Maintenance	.015
Total cost per cu. yd.	.09

This material was handled by three 12-ton dinkey engines, each hauling nine 4-cu. yd. cars and side dumped from a 65-ft. fill. Two trucks were used alternately on the fill, as the material was of a wet nature and it was impossible to hold one track for more than one or two days dumping. Accompanying this is a view showing construction on one of these fills.

Very truly yours,

B. M. Laughead,
Resident Engineer, C., C. & O. Ry.

Forest City, N. C., May 6, 1909.

A HIGH FILL ON THE CAROLINA, CLINCHFIELD & OHIO RY.

Public Expenditures for Inland Waterway Improvements.

Sir: The editorial in your issue of May 6, 1909, headed "Public Expenditure for Inland Waterway Improvements" is extremely worthy of careful study as well as the papers published in the same issue and to which you call attention. You have covered the entire subject so thoroughly by statement of fact or by pointing out the questions that must be solved and investigated before a comprehensive and economical plan of improvement can be adopted, that the writer can add nothing new and will merely attempt to further illustrate by citing conditions and cases coming under his observation.

This is a problem of such great magnitude and of such vital importance to the whole country that each and every one having special knowledge bearing upon the same should freely submit it for discussion; or at least be encouraged to do so. The writer has reference here to the censorship or muzzle placed upon the officers and their assistants of the Engineer Corps. The very men having an intimate and accurate knowledge, through long experience in the actual construction of such works as may be needed in the final solving of these problems, and the men upon whom we will finally place the task of executing such works as are authorized, are not being heard as they should be at this particular time.

It is true we get many very valuable professional papers describing details of construction and of cost, such as the one by Colonel Townsend on the "Improvement of the Upper Mississippi River," an abstract of which you printed in your issue of May 6. Very often, however, these papers fail to contain the opinions of the writers, or a full discussion pro and con covering the economical features of the problem in hand.

On the other hand, it is a fact that when opinions are advanced, or even physical facts published that are not entirely in accord with the opinions of those higher in authority, the officer so offending is sometimes reprimanded and admonished, directly or indirectly, regarding his boldness in appearing in print.

Not many years ago it was the custom to publish in the "Reports of the Chief of Engineers, U. S. A." many of the detailed reports of the Assistant Engineers in actual charge of the work, as well as lengthy reports of the officer in general charge based upon the information contained in the reports of his assistants. The detailed reports are now entirely eliminated, and those of the officer usually consist merely of a resume of the actual work with list of expenditures for the same.

In the early days of the nation, when the works under charge of the Engineer Corps were almost entirely those built as a protection against possible invasions by foreign foes, it was eminently proper that no information be given out; but today, when a very large part of the work of these engineers vitally concerns the commercial development of the nation it is not apparent why much information that is now withheld could not profitably be published.

Would it not at this time be advisable to send out over the country paid lecturers from the Engineer Department to present facts as to the probable costs of construction and maintenance of the works that would be required for the improvement of the navigable streams, so that the general public could draw conclusions from the business point of view as to the probable benefits; for it is quite true, as you state, that "false and most foolish statements regarding the public benefits to result from expenditure on waterways are being circulated about the country."

In former years it was too often the case that the sum and substance of the local interest in any particular improvement was based upon the fact that the prosecution of the work would be the means of circulating, in the community, just so much money. This brought about the trading of votes in Congress, which on several occasions led almost to a scandal. Fortunately this condition has materially improved for the better within recent years, due primarily to the fact that Congress had the courage to direct that all projects should first be passed upon by an advisory board from the Engineer Department. So long as such a sentiment prevails or has only a small influence, Congress itself, much less the Corps of Engineers will be powerless to entirely prevent expenditures that are not economically warranted.

The National Rivers and Harbors Congress has much additional work to do besides arousing public sentiment so that it will approve the expenditure of large sums of money upon the nation's waterways; and it has very wisely started the same by advising that the U. S. Engineer Corps be given authority to formulate and propose to Congress plans and projects for river and harbor improvements. We have no other body of men—and when we say this we include the great number of civilian assistants who have spent their entire professional life in this work—so well fitted by thorough experience to make such estimates.

We note criticism, and some of it from high authority, which seems to be aimed directly at the Engineer Corps of the Army and not at their Engineer Assistants; one objection being that they are moved from one station to another about every three years. It would appear, from one point of view at least, that this is a most excellent thing to do; so long, as is generally the case, one or more competent civilian engineers remain constantly on the work; for it will more quickly give the members of the Corps the general and broader view, so much needed in the handling of the whole problem, which some authorities have stated they lack.

The wide and generally informed "head" with the expert "sub-heads" is generally believed to be the ideal organization and this it would appear we now have in the present Engineer Corps and their Assistants. It is true that they are generally underpaid as compared with similar positions under private management, and this results in the loss to the government of the services of trained men at the very time when they have become most valuable.

It is not a difficult matter to single out individual projects planned many years ago and show that they have failed to be of commercial benefit, and it is not one bit more difficult to criticise the engineers having had the work in charge. It would have been difficult, however, to have planned at that same time works that would have proven of more service; for in no other branch of engineering work is it so difficult to predict probable results and figure costs and benefits.

In some instances we note severe criticism because the plans were not changed to conform with the increased size of boats; while in other cases the criticism is on account of the plans having been changed for this purpose. There is certainly very much misunderstanding of these questions on the part of many of us, hence the urgent need of more discussion, and the advisability of having the Engineer Corps and their assistants enter into the same.

Many criticize without proposing any substitute and therefore their criticism is of small weight. Those that do propose a different organization for the handling of river improvements, simply substitute civilian engineers for army engineers. We can see no good reason for this. The engineer officers engaged in river and harbor improvements have, with few exceptions, been so engaged ever since they left college, and although a part of the army organization in fact, are not so in actual practice. And they have had more extended opportunities as a rule than the civilian engineers to become proficient in the general supervision of such improvement works.

Yours truly,

Chas. H. Miller,
Engr. River Protection, Mo. Pac. Ry. Co.
Little Rock, Ark., May 24, 1909.

Earthwork Diagrams for Estimating Quantities in Small Irrigation Canals in Level Section.

Sir: Herewith is a diagram which the writer has found very useful in estimating quantities of excavation and embankment in small irrigation canals in level section. As a large proportion of small irrigation laterals are in level section, the value of the curves as a labor saving device may be readily appreciated.

All necessary information concerning the curves is shown on the diagram. The "Typical Sections" explains the nomenclature and all equations are indicated. Several brief examples will suffice to make the diagram readily understood.

CASE I. For this case the canal may be either in thorough cut or partial cut with embankment on either side. For thorough cut the quantities are read direct on the upper curves and no attention is paid to the fill curves. For partial cut, the excavation may be greater, less than, or equal to the embankment. Which of these conditions the particular problem in hand comes under is determined from the diagram. For example, consider the problem shown in Fig. 1.

Enter the diagram at the diagonal line $C = 2$, follow this line diagonally upward to the vertical line marked "Values of C," thence along the horizontal line to the intersection with line $b = 3$, thence vertically downward, reading directly cut $V = 44$ cu. yds. To read "fill" enter the diagram at $C = 2$; follow the diagonal line from this point to its intersection with the vertical line marked $d + h = 3$; from here follow horizontally to the right to the curve $a = 2$ and read $V_1 = 26$. It thus appears that the excavation exceeds the fill and no borrow is necessary. If by a similar process it is found that the cut equals fill, no borrow will have to be figured on unless an allowance is made for shrinkage in the fill. An allowance for this could be made in plotting the curve but is not made here because it is not a constant and depends on the nature of the soil, method of depositing the earth, etc. Further, if by a similar process, it is found that the fill exceeds the cut, an allowance must be made for borrow or overhaul as the case may be. (This is not necessarily true as the next station may be in deeper cut and be within the free haul limit, but the statement is made merely as an illustration of a possible case.)

CASE II. In this case the canal is entirely in fill and two quantities must be looked out from the diagram to make up the total fill. In calculating fills, the simplest process is to calculate the sum of the two embankments

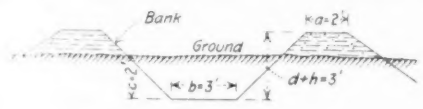

Fig. 1.

considered as full trapezoidal sections with bases "a." Referring to the "Typical Sections" shown at the bottom of the diagram, it will be seen that for the condition there represented as "Case II.," we must deduct from the total quantity thus obtained the volume of the lower shaded triangular prism and add the volume of the upper shaded triangular prism. The algebraic sum of these two triangular prisms may be either positive, negative or zero, depending on whether the upper prism is greater than, less than, or equal to the lower prism. The general

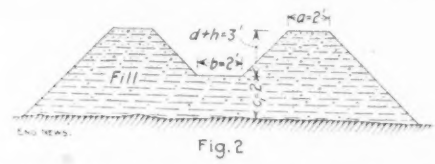

Fig. 2

equation for this sum is $E = -.617\ [(3c_1 - b)^2 - b^2]$. The plot of this equation on the diagram shows the positive values of E on the left of the vertical axis, negative values on the right and zero values at the intersection of curves with the vertical axis. The complete equation for embankment in Case II. is:

Total Volume $= V_1 + E = 7.4\ [a\ (d + h + c_1) + 1.5\ (d + h + c_1)^2] - 0.617\ [(3c_1 - b)^2 - b^2]$.

Now for an example coming under Case II., take the following problem shown in Fig. 2.

To get V_1, enter the diagram at $C_1 = 2$ (or $C = -2$); thence follow diagonal line to $d + h = 2$; thence horizontally to the right to the curve marked $a = 2$ and read $V_1 = 237$ cu. yds. on the lower scale. Now to get E, enter the diagram at the same point, $C = 2$; thence horizontally to the right to the curve for E marked $b = 2$ and read -8 cu. yds. The net fill, then, is $V_1 + E = 237 - 8 = 229$ cu. yds.

The object of using two different scales for the values of V_1 is merely to shorten up the diagram, the lower set of curves for V_1 being merely a continuation of the four upper curves, and the lower scale a continuation of the upper.

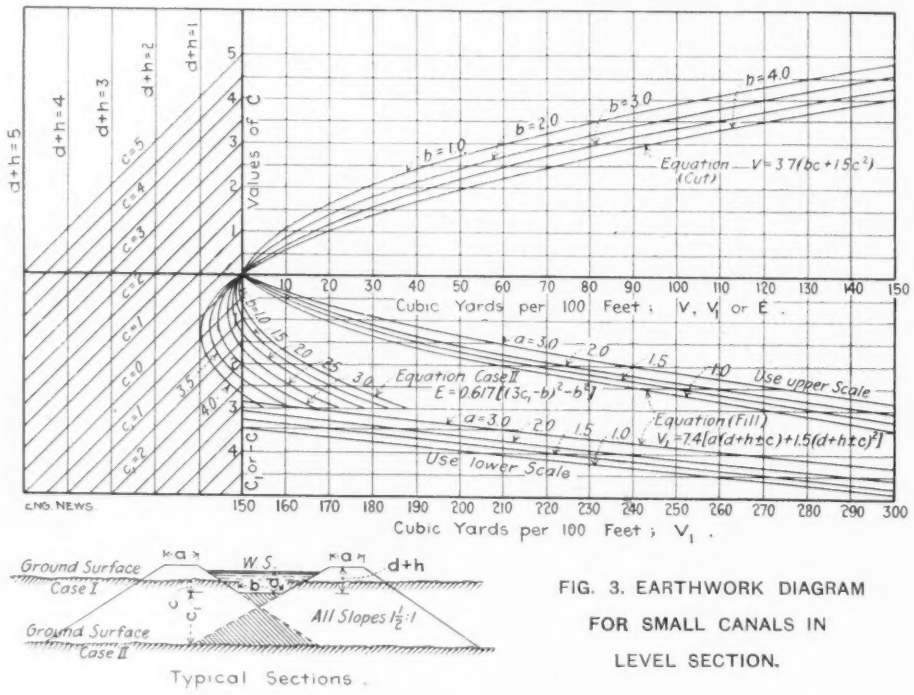

FIG. 3. EARTHWORK DIAGRAM FOR SMALL CANALS IN LEVEL SECTION.

These curves were first brought to the attention of the writer by Mr. O. G. Patch, Field Assistant, U. S. Reclamation Service, who, I believe, is the originator of the idea.

Very respectfully,

E. A. Moritz,
Asst. Engr., U. S. Reclamation Service.

Sunnyside, Washington, May 6, 1909.

Earthwork Calculations for Side Hill Work.*

Sir: In connection with our work of making a survey and estimate for the double-tracking and relocation of the Lehigh & Hudson River Ry., I have worked out the following method for calculating the correction of level section quantities for side hill work.

In Fig. 1 $S\,S'\,B'\,B$ represents any cross-section in a

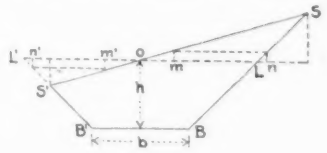

Fig. 1.

cut and $L\,L'\,B'\,B$ represents the level section having the same center height; h = center height of the section; b = the base; s = the horizontal distance for 1 ft. rise in side slopes; p = per cent. of the side hill grade.

The level section correction is the difference in the areas of the triangles $S\,L\,O$ and $S'\,L'\,O$, and a general expression for this difference will therefore be also a general expression for the above correction.

The length of $O\,L$ and of $O\,L'$ is $\frac{b}{2} + s\,h$.

Draw two lines parallel to $L\,L'$, the one 1 ft. above and the other 1 ft. below it, and also draw the perpendiculars m, n, m' and n',

$$O\,m = \frac{100}{p}. \quad L\,n = s.$$

$O\,m - L\,n = \frac{100}{p} - s$, which is the amount by which the base of the triangle $S\,O\,L$ becomes shortened when its altitude is reduced by 1 ft.

The altitude = the base divided by the shortening of base per ft. reduction in altitude

$$= \frac{b/2 + s\,h}{100/p - s}$$

Then the area of the triangle

$$S\,O\,L = \frac{1}{2}\left(\frac{b/2 + s\,h}{100/p + s}\right) \times (b/2 + s\,h)$$

Similarly the area of the triangle

$$S'\,O\,L' = \frac{1}{2}\left(\frac{b/2 + s\,h}{100/p - s}\right) \times (b/2 + s\,h)$$

The difference in the areas of these two triangles is

$$\frac{1}{2}\,\frac{(b/2 + s\,h)^2}{100/p - s} = \frac{1}{2}\,\frac{(b/2 + s\,h)^2}{100/p + s}$$

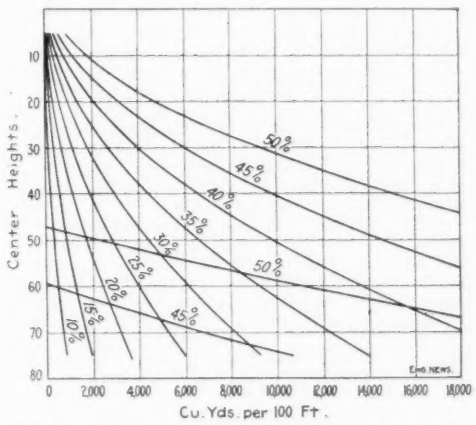

Fig. 3. Diagram for Earthwork Quantities in Side Hill Work.

18-ft. Roadbed, 1½ to 1 Slopes.
Correct within 10% for 14 — 22 ft. roadbeds.

Formula $\frac{100}{27} \times \frac{p^2 s}{10{,}000 - p^2 s^2}\,(\frac{1}{2}\,b + s\,h)^2$

p = Grade side hill in feet per 100 ft.
s = Hor. dist. per 1 ft. rise in side slope of X-Section.
b = Base of roadbed in feet.
h = Center height of X-Section in feet.

*This letter was originally printed in our issue of May 27, 1909, p. 582. On account of certain inconsistencies in the nomenclature and the omission of a cut at that time, we are reprinting it here in revised form.—Ed.

Table of corrections of Level Section quantities for side hill slopes

	$\frac{100}{27}\,\frac{p^2 s}{10000 - p^2 s^2}$	.056834	.131665	.244200	.404040	.626939	.933507	1.388888	2.066550	3.174603
$(\frac{b}{2}+sh)^2$	Center Height	10%	15%	20%	25%	30%	35%	40%	45%	50%
27225	5	155	358	665	1100	1707	2558	3781	5626	8643
57600	10	430	758	1406	2327	3611	5411	8000	11904	18286
99225	15	564	1308	2423	4009	6221	9322	13781	20506	31500
152100	20	864	2003	3714	6145	9536	14290	21125	31433	48286
216225	25	1230	2847	5280	8736	13556	20315	30031	44685	68643
291600	30	1657	3839	7121	11873	18282	27396	40500	60261	92571
378225	35	2150	4980	9236	15282	23713	35535	52531	78164	120071
476100	40	2706	6268	11626	19236	29849	44730	66125	97242	151143
585225	45	3326	7705	14291	23645	36691	54992	81281	119794	185786
705600	50	4010	9290	17231	28509	44238	66291	98000	145819	224000
837225	55	4758	11023	20445	33827	52490	78658	116281	173020	265786
980100	60	5570	12904	23934	39691	61448	92081	136125	202547	311143
1134225	65	6446	14933	27698	45827	71111	106561	157531	234398	360071
1299600	70	7386	17111	31856	52509	81480	122058	180500	268574	412571
1476225	75	8390	19437	36049	59645	92553	138692	205031	305075	468643

Earthwork

Sta.	Level sec. Quantities	CUT Transverse Slopes	Slope Correction	Total Cuyds.	Level Sec. Quantities	FILL Transverse Slopes	Slope Correction	Total Cuyds.
119	8250	42%	5600					
120				13850	3000	15	150	3150

FIG. 2. TABLE OF CORRECTIONS OF LEVEL-SECTION QUANTITIES FOR SIDE HILL WORK (CU. YDS. PER 100 FT.); LEHIGH & HUDSON RIVER RY.

which can be reduced to

$$\frac{p^2\,s}{10000 - p^2\,s^2}\,(b/2 + s\,h)^2$$

This expression multiplied by $\frac{100}{27}$ is the general expression for the correction of level section quantities in cubic yards per 100 ft. for side hill slopes. Since inverting the figure does not change the relation of any of its parts the same formula holds true for fills also. By inspection it can be seen that these quantities will always be additive.

The expression $\frac{100}{27} \times \frac{p^2 s}{10{,}000 - p^2 s^2}$ is constant for any center height and the expression $\frac{b}{2} + s\,h$ is constant for any grade of side hill. The accompanying table (Fig. 2) has been worked out with this in view. The first two columns are filled out. Then the quantity for each remaining space is found by multiplying together the corresponding values of the columns mentioned above. Much tedious work will probably be saved by using this form.

The diagram plotted from this table (Fig. 3) is self-explanatory; values for intermediate slopes can be found by interpolation. When the roadbed is 18 ft. wide and the side hill grade is 50% the formula does not hold true for a cut or fill under 4.5 ft., as the side hill grade under these conditions will strike the subgrade inside of the slope. So far as I am able to find, a diagram of this sort has never been worked out before, and it can be made a valuable refinement in paper location work.

If in the expression $\frac{100}{27}\,\frac{p^2 s}{10{,}000 - p^2 s^2}\left(\frac{b}{2} + s\,h\right)^2$ when the base b is changed to any other width b' the center height is given the value $h - \frac{b' - b}{2\,s}$ the value of the expression will not be changed. The term $\frac{b' - b}{2\,s}$ is constant for any center height. It follows from this that a correction diagram for one width of roadbed can be used for cross-sections of any other width of roadbed having the same side-slopes, by adding a constant to all center heights. For instance, the 18-ft. base diagram (see Fig. 3) may be used for any 30-ft. base cross-section by reading from the diagram the correction for a center-height $\frac{30 - 18}{2 \times 3/2}$ or 4 ft. greater than the center-height of the cross-section.

One who has never stopped to consider the question might imagine that since the slopes are likely to run about as often one way as the other, the errors will average up in the long run. But this is not the case, as a moment's consideration will show that the errors are always accumulative, no matter which way the slope runs or whether the cross-section is in cut or in fill.

In our paper location work we use a regular profile quantity scale, arranged as shown in Fig. 4, and read the level section quantities directly from the profile. These quantities are noted in their proper columns in the standard form. Next a man runs over the trial line and calls off all transverse slopes over 10%; the grades of the slopes are found by counting the number of contours in 50 or 100 ft. The correction column is then filled out by reading from the diagram the correction corresponding to the side hill slope and the center height or level section quantity at each station. In the total quantity column only the sum of all of the level section plus the sum of all of the correction quantities in each cut or fill are noted.

When the work is carried on in this way it will save time in reading the level section correction diagram if each line representing some foot of center height is marked with the level section quantity corresponding to that height.

Yours respectfully,

Robert S. Beard.
Asst.-Engr., Lehigh & Hudson River Ry.

Warwick, N. Y., May 27, 1909.

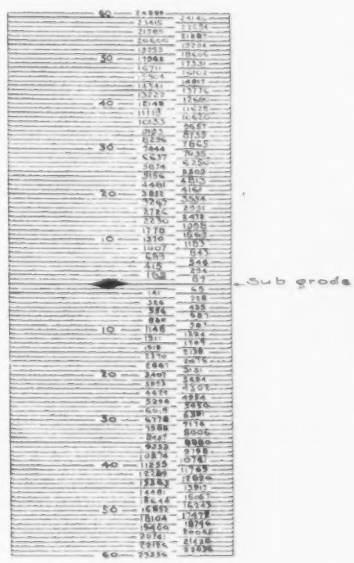

Fig 4. Quantity Scale for Preliminary Estimates of Earthwork.

(Note.—To find the earthwork yardage at any station, place the right-hand end of the zero line on the grade line at that section, and read the yardage opposite the line which meets the profile.)

Standard Methods of Analyzing Water for Bacteria Contents.

Sir: I note two communications in your issues of April 22 and May 13, 1909, respectively, concerning standard methods of water analysis, especially with reference to the significance of bacterial counts in the control of water filters. In view of the fact that these letters may produce an erroneous impression in the minds of some of your readers, a statement of the present status of bacterial water analysis and of some of

the peculiar conditions which greatly retard American progress in this line, appears to be called for.

Both of your correspondents appear to regard the fact that the bacterial counts, and the bacterial removals by water filters computed from those counts, may be influenced to a considerable degree by the time of incubation as a new subject. As a matter of fact it has long been known to water bacteriologists that the numbers of bacteria in water and sewage, as determined by the ordinary procedure, are influenced not only by the time of incubation, but also by the temperature, and that small variations in the composition of the media employed, variations which are often beyond the control of the operator, may cause a very considerable fluctuation in the results. This subject has been continuously under investigation for more than twenty years at the Lawrence Experiment Station, and has received attention in nearly every water laboratory throughout the world.

The effect of varying periods of incubation, of different temperatures and of varying composition of culture media upon bacterial counts was tabulated and discussed in the 1895 report of the Massachusetts State Board of Health, and the results obtained in later investigations at Lawrence, covering a wide range of conditions, were discussed in two papers by the writer at the meetings of the American Public Health Association in 1901 and 1903, respectively. In the latter paper the effect of different variations in the analytical methods upon the computed bacterial removal by water filters was very completely covered. Certain other phases of the problem were further discussed in the 1906 report of the Massachusetts State Board of Health. Bacteriology, dealing with living organisms, subject to all the variations and mutations known to biology, never has been and never can be an exact science, and this should be clearly recognized by all who have occasion to apply the results of bacterial analyses. Nevertheless, when its limitations are understood and its results are correctly interpreted, bacterial analysis occupies an important place in the control of public water-supplies and of water purification systems.

With reference to the standard methods of water analysis, the writer was a collaborator with the earlier committees, and is a member of the present committee on standard methods of bacterial analysis, and is thus in a position to know some of the difficulties against which these committees have had to labor. While fully realizing that the procedures in some laboratories were more accurate than the methods adopted, it was necessary to formulate the standard procedure in such a way that it would conform as closely as possible to the methods in use in the greatest number of laboratories in order to secure its immediate acceptance by the greatest number, and to obviate the confusion and opposition which would result from too great a change. Since the first standard methods were adopted a number of supplementary reports have been made in which many improvements have been introduced, with the result that the results of analyses and their interpretation are becoming more accurate and more uniform.

Much of the misunderstanding which has existed in this country in the interpretation of the results of sanitary analyses, both bacterial and chemical, is due to the peculiar relations of the engineer and the analyst. The correct interpretation of a sanitary water analysis requires an intimate knowledge, not only of the meaning of the various results, but also of the details of the methods by which they were obtained, and, further, of the bearing of the constantly increasing mass of experimental data upon the significance of the results, individually and collectively. In European countries the control of water-supplies and water filters is usually in charge of men who have had long experience in the laboratory, who thoroughly appreciate all these conditions. Under such circumstances, each advance in methods of analysis and in the significance of the results, has been promptly and correctly applied in the interpretation. In this country, however, an entirely different practice is in vogue. The interpretation is frequently made by an engineer who has had no actual experience in laboratory work and whose knowledge of the methods of analysis and whose appreciation of the rapid advances which are taking place in sanitary chemistry and bacteriology are often extremely limited. The standards by which such interpretations are made are as old as they are fixed in the minds of their users, and any attempt to introduce newer and more accurate methods of analysis, by the use of which the standards of interpretation will have to be modified, meets with strenuous opposition by those in authority. Under such conditions improvements have had to come very gradually, since after the analysts have become convinced of their desirability, those who apply and interpret the results must be educated to the changed significance which newer and more accurate methods will introduce. Fortunately, the number of sanitary engineers who have worked up through the laboratory is rapidly increasing.

Yours very truly,

Stephen DeM. Gage,

Biologist, Lawrence Experiment Station,

Massachusetts State Board of Health.

Lawrence, Mass., May 21, 1909.

The Eads Bridge and the Quebec Bridge; A Comparison of Different Methods of Bridge Designing.*

By CARL GAYLER,† M. Am. Soc. C. E.

About 40 years ago, or, to be more accurate, on Feb. 26, 1868, the first stone was laid on the Eads Bridge; in 1872 work was begun on the East River Bridge, and in the fall of 1876 erection of the first cantilever bridge in the United States, Smith's Kentucky River viaduct, was started. So, in the late sixties and the early seventies, bridge building in this country may be said to have entered on a new era.

It is not easy for us to realize the state of bridge building in those far-off days.

It was the time of the cast-iron top chord and post; or, in cases where patented wrought-iron columns—the Keystone, the Phoenix or similar columns—were used, it was, at least, the time of the cast-iron joint. The eyebar, used sometimes in forms which would appear very strange to us, was being developed, and a number of years passed by before pin-moments and pin bearings were taken account of; even the use of pins just as they came from the rolls, not turned off, was not unknown. The strain-sheet can hardly be said to have been in general use, and such strains as were calculated were worked out on the basis of uniformly distributed loads; even for floorbeams and stringers the assumption of concentrated loads was something unknown. It was still a general practice of the bridge builder to continue the counters to the end of the trusses, also to claim that wrought-iron stood an ultimate tensile stress of 60,000 lbs. per sq. in.; and, testing machines not being in general use, this claim went unchallenged. It is a noteworthy fact that in the contract for the superstructure of the Eads Bridge, for the first time in the history of American bridge building, elastic limit and modulus of elasticity were prescribed.

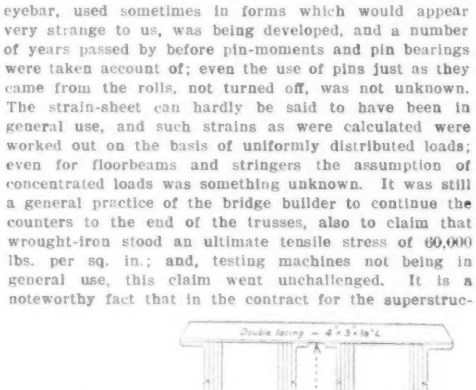

Fig. 1. Comparison of Sections of Chords of Eads Bridge and Quebec Bridge.

Now in these dark times, Captain Jas. B. Eads conceived and carried out the idea of building a steel arch bridge at St. Louis, over the Mississippi River. It is not necessary to tell you that the difficulties which had to be overcome were enormous. The very material to be used for the chords of the arches had actually to be discovered. The expression "infant industry," since so much abused, could in full truth be applied to the condition of manufacturing steel in those days, at least for such large members as the staves, enveloping sleeves and couplings of the Eads Bridge arches. The Eads Bridge was opened to traffic on July 4, 1874, and has carried its heavy loads, far exceeding any loads dreamed of at the time the bridge was planned, ever since, now 35 years.

In the summer of 1907 the great Quebec Bridge over the St. Lawrence River fell during erection, carrying down to sudden death over 90 men.

In spite of the disparity in magnitude and length of spans, the two structures are not unequal in boldness, if the time in which the Eads Bridge was built and the new material which was used are taken into account. Let us see what chances either of the two works *should* have had to survive the other, confining our comparisons to the superstructures.

The assumed live loads for the main arches of the Eads Bridge were: 2,000 lbs. per lin. ft. of each railroad track and 4,000 lbs. per lin. ft. of upper roadway, including sidewalks; total live load therefore equals 8,000 lbs., or 2,000 lbs. per lin. ft. of each arch. Both chords of the arches are continuous in the center and are anchored at their ends, thus representing a type of arch bridge not before attempted and requiring theoretical computations likewise not worked out before. The very proportions of the arches, with a versed sine of one-tenth, demanded the use of hard steel to avoid excessive temperature stresses. Let us look somewhat closer into the various features of this remarkable structure, which in the light of our experience of to-day would make it easy for any of us to explain, in case it did fail, why it did fail.

(1) The chords of the arches are built of hard steel, elastic limit 40,000 lbs., ultimate strength 100,000 lbs. Suitable steel for the parts composing the chords, i. e., the staves, enveloping shells and the couplings, was obtained after numerous failures, and no such uniform materials could under such conditions be obtained as the merchantable structural steel in use to-day.

(2) The assumed live-loads for the railroad tracks are about one-half of present-day practice, considering that no allowance was made for concentrated loads or excess of engine loads.

(3) The allowed unit stresses, on the other hand, 30,000 lbs. per sq. in. in compression and 20,000 lbs. per sq. in. in tension, exceed the unit stresses allowed to-day.

(4) No allowance was made for alternating strains in the arches.

(5) The computations, admirable as they are, presuppose a material with a uniform modulus of elasticity; furthermore a uniform sectional area of the chords was assumed with heavier sectional areas for the ends for a distance of one-twelfth of the length of the span. As actually built, there are six different sectional areas of the tubes.

(6) There was no attempt made to proportion the hard steel pins according to bending moments, nor, what is more serious, to proportion the heads of the wrought-iron diagonal eyebars according to their bearing on the pins.

The floor system, having since been strengthened or renewed, needs not to be gone into.

To sum up: the arch chords are of hard steel of far from uniform quality; the assumed loads are small; the allowed unit stresses great; the computations, to be at all feasible, were based on assumptions which do not coincide with the actual conditions. In proportioning the details, our experience gained during the forty years since the planning of the Eads Bridge was, of course, not available.

In the case of the Quebec Bridge, it is not necessary to enter into the question of loading and unit stresses at all. Like the Tay Bridge, like the Ashtabula Bridge, probably like every bridge that ever failed, it failed through faulty design, not through overloading. It is true that the specifications allowed higher unit stresses than the standard specifications of to-day, but we do not know, nor shall we probably ever know, whether the judgment of Mr. Cooper in this respect was at fault or not. According to the careful investigation of Mr. C. C. Schneider, the members which caused the downfall of the Quebec Bridge were at the time of failure stressed to a pressure of less than 20,000 lbs. per sq. in. Now, if our work were liable to succumb under such a stress, the sleep of us poor bridge engineers would be as surely "murdered" as old King Duncan's.

The failure of the Quebec Bridge is due to faulty design; the success of the Eads Bridge is due to its admirable design; and, in trying to explain and illustrate this, I wish also to call your particular attention to the position which the engineer, the man who did design and plan a structure, used to hold and should hold and does not hold to-day.

Fig. 1 shows the cross-section of the main compression members of the Eads and the Quebec bridges. They tell their own tale; the tubes of the former the ideal shape to resist compression, the latter probably the most unfortunate shape ever prepared by man for a compression member. A great deal has been written on the latticing adopted for these chords, and there is no doubt that a double lacing of 3 by 4 by ⅜-in. angles is more appropriate for a 400 or 500 ft. truss bridge than for an 1,800 ft. cantilever span; but, assuming that the latticing had been designed of sufficient rigidity to hold the four webs in line, what would have prevented the webs themselves, 54 ins. high and about 4 ins. thick, from bulging?

Now, somewhat to explain the remarkable fact that such a shape could be proposed, could be built in the shop and put in position, unchallenged, let us go back to where we considered the era of bridge building forty years ago. Those master bridge builders, Eads and Roebling, passed away and new factors began to make themselves felt. Mr. Theodore Cooper, formerly chief inspector for the superstructure of the Eads Bridge, published the first standard specifications for railroad bridges, and it can truly be said that no one man has exerted a like influence on the evolution of the American bridge. His great ability, his utter conscientiousness, his ceaseless study of the requirements of bridge work under changes of material and loading, were rewarded by the fullest confidence, a confidence justified by the success of all bridge work based on his specifications. Few facts are more pathetic than that this man, towards the end of his career, was overtaken by fate and failed in the greatest work with which his name has been connected.

About the time of the publication of Mr. Cooper's first standard specifications, a new class of professional men, the bridge engineers, can be said to have made their appearance, with the building of the Cincinnati Southern

*From a paper read before the Engineers' Club of St. Louis, Feb. 17, 1909, and printed in the "Journal of the Association of Engineering Societies," March, 1909.

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ft. R., about 1876. The times of rule-of-thumb disappeared and to the trained bridge engineer we owe the present perfection of bridge work in all its details. The importance of detailing with a view of facilitating the work in the shop began also to become an important feature in bridge designing. In short, bridge superstructures began to be manufactured like steam engines or dynamos, the design became more or less routine work, American bridge companies competed successfully in foreign countries with English and German firms; things were running in tolerably worn channels.

It was all so easy. Perhaps too easy. All a man had to do was to specify for his bridge or trestle or viaduct Cooper's A, B or C, as the case might be, check the strain sheets and details submitted by an obliging bridge company and turn the inspection over to some inspection company; it was, as Hamlet says, "as easy as lying."

Now all of this may appear to be expressed too strongly, and it is too strong for 99 cases out of 100. But in the hundredth case, and the hundredth case just includes work of unprecedented character, this routine system fails, and to explain this failure as demonstrated by the Quebec Bridge, let us consider somewhat more fully the standard compression member of American bridges.

After abandoning cast-iron for compression members, the uniformly adopted cross-section was the box or U-shape, one side left open and laced for the connections with the web members. This U-shape is an exceedingly serviceable shape and a good shape. With an increase of square inches in the section, the horizontal member served more and more merely as lacing or tie for the two vertical (web) members. But with still further increase of the sectional areas, and especially on account of the pin moments, this two-webbed section became insufficient and the step to the four-webbed section was easy and natural. The four-webbed section was also a serviceable section, very convenient for the work in the shop, but it was, essentially, not an advantageous section to resist compression. The angles at top and bottom of the webs, necessary for stiffening and for the connection with the lacing or plates which connect the webs, were furthermore found to be in the way of the posts and diagonals and liable to be curtailed in the design. So we see that the faulty compression members in the shore arm of the Quebec Bridge are not an isolated case in American bridge work. They are the end, the limit reached in a line of evolution, of an objectionable design, adopted without misgivings in former work and also, for example, on the Memphis, Thebes and Blackwell's Island bridges.

And why should there have been misgivings? There were no testing machines available for testing compression members of such sizes and lengths, and American bridge building stood so high in the estimation of the world that no voice was raised against the routine into which we had fallen in the design of compression members.

Now, to resume our comparison of the Eads Bridge and the Quebec Bridge. The Eads Bridge is called by Mr. David A. Molitor "a model of aesthetic design." An unprecedented amount of labor and time, in the St. Louis office, was spent in merely "proportioning" it. The structure would have been just as serviceable if the three arches had been of equal length, if the center arch and the adjoining ends of the side arches had been on a level with the bearings at the abutments, if the grades of the railroad and roadway floors had not been built to the exact lines of parabolas. It is true the beauty of the tubes, with their compactness and simplicity, was partly obtained by striving for the advantage of a protection of the compression members, the six enclosed staves, against atmospheric influences in a manner superior to any other bridge member known except the wires of the Roebling cables inside of their wire wrappings. The wrought-iron skewbacks, Fig. 2, which on their cast-iron bed-plates distribute the pressure of the tubes over the granite bearings, have always seemed to me to be of a design to be admired beyond any bridge pedestal ever designed. No doubt they were expensive and anything but "convenient for the shop"; in fact, there could be found, in those days, only one shop in the country, way up in New Hampshire, with a steam hammer powerful enough to forge them. But is not, in permanent structures built in our large cities, beauty of design justified even at somewhat increased cost? There is not an ornament added to the Eads Bridge, its beauty is all in its proportions.

And here I beg leave to put on record the fact that this proportioning, this designing of our bridge, was the exclusive work of James B. Eads. The credit for this was never before given to him, but it is due to him as surely as the exclusive credit for the computations is due to Mr. Charles Pfeifer, and the exclusive credit for the bold manner of erection to Col. Henry Flad. The opinion which I herewith put on record as the last man living who followed and took part in the work of designing the Eads Bridge in the office, if in a subordinate position, should be of some weight.

The plans of the Quebec Bridge were prepared by the engineers of the Phoenix Bridge Co., based on the specifications adopted by the Quebec Bridge Co. and afterwards modified by the consulting engineer, Mr. Cooper. It is the simple shape of a cantilever known to us almost to satiety. Somewhat striking in the design is the evident reduction of masonry to a minimum. If the bridge had ever been completed, its most striking feature, however, would have been its two main towers, each consisting of two vertical legs, 5 × 10 ft. each, 67 ft. between centers and 315 ft. high, with lateral bracing between. There is no parallel to such a tower; the legs have no better; they are pin-bearing at both ends; nothing whatever has been done to give the towers the appearance of stability or massiveness which might have been expected from their height and the duties they would have had to perform. I leave you to judge of such a design yourself, and will only add that it is a great pity the Quebec Bridge broke down as soon as it did. It might have become a very interesting object lesson.

A cantilever bridge has some peculiar features which distinguish it from the ordinary truss: The loads imposed on the center span produce strains which have to travel great lengths till they reach the anchorage, which fact accounts for the great deflections inherent to this system. The bottom chords—and this is more important even, especially where built in the form of an arch, as in the Quebec Bridge—have to be held rigid by the web system. Now, consider that the bottom chord of the shore arm of the Quebec Bridge, the member whose failure caused the downfall of the structure, with its calculated pressure of ten thousand tons, had thus to be held rigid by the top chord and by means of a web system over 100 ft. high at one end and over 300 ft. high at the other end. The great Forth Bridge has been called a "monstrosity," and not unjustly; yet there is that in its design which takes into account the great duties it has to perform and which might well have

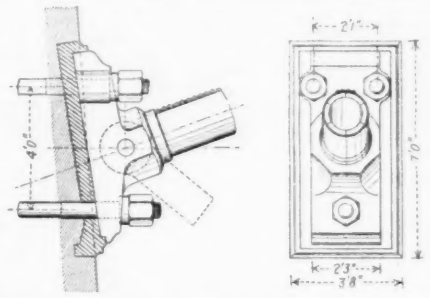

Fig. 2. Forged Iron Skewback Bearings of Arch Ribs (Eads Bridge Over Mississippi River at St. Louis, Mo.).

served as a lesson to the engineers whose names are connected with the Quebec Bridge. Consider also that, for a reason which will be touched upon further on, "the actual unit stresses in some of these web members are in excess as much as 21%, in one case 50% of the limits of the specifications" (C. C. Schneider), the specifications themselves, as above remarked, allowing unit stresses in excess of present-day practice.

Do not misunderstand me: This is not said in a spirit of fault finding, but it is our duty to try to profit from such lessons. What I have brought before you so far was brought forward principally to impress on you the fact that bridge building cannot become a matter of routine without great danger. There is no doubt that the Quebec Bridge superstructure consisted of excellent material; no fault can be found with the inspection; the structure is simple and the stresses could be accurately ascertained. The details were admirably adapted to the work in the shop—what more desirable shape for shop work could be designed than the four-webbed compression members, each web consisting of 4 plates, 4½ ft. wide, with angles at the ends and connected by lacing?

Of real "designing" there was practically none; the exigencies of the shop seem to have overshadowed everything. In examining the plans of the Quebec Bridge, we get the impression that the one paramount idea, from the conception of the general plans down to the minutest detail, over-riding every principle of true designing, not to speak of any considerations of aesthetic effect, was to obtain a superstructure which could be built with the greatest ease, the greatest dispatch and at a minimum cost by the shops of the Phoenix Bridge Co. It is not too much to say that the position of the consulting engineer approached close to that of an examining and auditing chief clerk; and the bridge company's engineer, through the demands of the shop for additional shop drawings, was hurried so that not even sufficient time was given him to carefully plan and carefully estimate and check the weights of the different members of the structure. This is admitted in Mr. Cooper's testimony and conclusively proven by the one fact that, after the bottom chords of the west shore cantilevers were completed in the shop, the weight of the 1,800-ft. center span was found to exceed the formerly estimated weight by, according to one testimony, as much as 25%. It seems next to incredible that this greatest bridge undertaking of our day should have been thus mismanaged, and that the engineers connected with it acquiesced and lent their approval to it.

To speak of the compensation which the consulting engineer received for the work thrust on him, and for his tremendous responsibility, would be too painful.

The position of the bridge engineer, both of the company's engineer and of the consulting engineer, had with the Quebec Bridge reached its lowest level. Not that this case can be considered as the universal practice of to-day, but the magnitude of the work could not but help to bring this question glaringly into the light.

Melting Steel for Castings.

At the annual meeting of the American Foundrymen's Association, held at Cincinnati on May 18 to 21, some important papers were presented on furnaces for the melting of steel for castings. In presenting two papers, whose authors were absent, Dr. Moldenke, Secretary of the Association, referred to the development of the electric furnace. In Europe there are 70 or 80 of such furnaces, but it is notable that they are established at points where water-power is available and are thus far removed from industrial centers. This could not be a successful arrangement in commercial work. Steel has been made direct from the ore in these furnaces, but the cost is higher than the price which can be obtained for castings. In his opinion, the way to develop the electric process commercially is to make it an auxiliary of the ordinary foundry, and to do 90% of the work by a low-cost process. The charge will be prepared in the heating furnace and transferred to the electric furnace for a finishing treatment to produce a fine grade of steel. A foundry can then make ordinary steel castings all day, and then take a few finishing heats with the electric furnace for a higher grade of steel for special castings.

An interesting paper on "The Cost of Steel Melting in Foundries" was read by Dr. Bradley Stoughton, in which he discussed the details of cost by different processes. While the open-hearth system has been successfully used for small castings, yet ordinarily it is not successful for such work; the metal is not hot enough for the pouring of a number of small castings from one large ladle, and there is also a loss by the spattering of such a ladle at small molds. The United States Steel Co. is using the continuation process suggested by Dr. Moldenke; the charge is made in Bessemer converters, and is high in phosphorous. It is then dephosphorized and desulphurized in the electric furnace at a cost of about $3 per ton, with electric current at 1 ct. per KW.-hr.

The figures given by Dr. Stoughton we have summarized below. The "cost of metal" includes the pig iron, the heads and gates, the defective castings due to bad metal, and the ferro-alloys. Of the steel in the ladle, 65% goes into the castings, 33% into the heads and gates, etc., and 2% is lost by spattering.

COST OF STEEL CASTINGS.
(Per Ton of 2,000 Lbs.)

Process	Cost of metal.	Operating cost.	Cost of steel In ladle.	Cost of steel In castings.
Acid open-hearth	$15.64	$5.50	$21.14	$27.90
Acid open-hearth	15.64	8.85	24.69	33.06
Basic open-hearth	14.87	6.10	20.97	27.64
Basic open-hearth	14.87	9.55	24.42	32.04
Acid and basic O-H in one plant { Acid	15.48	5.50	20.98	27.66
Acid and basic O-H in one plant { Basic	13.93	6.10	20.03	26.19
Converter	19.37	3.50	22.87	30.56
Converter	19.37	5.50	24.87	33.64
Converter, with large waste	20.92	3.50	24.42	32.95
Converter, with large waste	20.92	5.50	26.42	36.03
Acid O-H for small castings	17.42	5.50	22.92	30.64
Acid O-H for small castings	17.42	8.85	26.27	35.79
Basic open-hearth for small castings	17.98	6.10	24.08	32.45
Crucible	22.83	35.00	57.83	83.00
Crucible	15.13	35.00	50.83	71.33
Electric, 1 ct. per KW.-hr.	11.81	....	28.81	39.03
Electric, 3 cts. per KW.-hr.	11.81	....	47.11	66.76
Electric, 5 cts. per KW.-hr.	11.81	....	65.41	94.49

The electric furnace process has the advantages of using the cheapest form of scrap and of turning out the highest grade of finished product. But it can hardly be expected to compete in cost of production with any of the other processes except the crucible process, and then only when electric power is available at a cost of not more than 3 cts. per KW.-hr. It is possible, however, that developments in the electric process may so reduce the cost as to compete with, or even supersede to some extent, the converter process,

especially in view of the high grade of steel produced by the electric process.

The other two papers on the melting of steel for castings related respectively to converters and to open-hearth furnaces for small charges. Abstracts of these are given below:

The Side-Blow Converter for Steel Castings.

By J. S. WHITEHOUSE.*

The side-blow converter has firmly established itself in America, and has overcome the strong prejudice against it. When it was first introduced, absurd claims were made for it. According to the agents, castings could be made practically the same as in gray iron practice. With the exception of the blower for the vessel, all the equipment required was that of the ordinary iron foundry. The claim was based on the fact that the steel was hot enough to pour over the lip, and from small ladles. The next claim was that any man with ordinary sense could in a few weeks learn to operate the process. The castings made in green sand were superior to castings made in open-hearth by high-priced men. It was not necessary to head nearly so heavy as in open-hearth practice, as the liquid metal took care of the shrinkage, and it was possible to get as high as 80% of castings.

The objections raised by open-hearth men were based principally on the heavy loss in blowing and irregularity of product. The castings made in green sand were mostly blow holes when machined, and the metal checked and shrank like any other steel. The steel when tested was found to be no better than acid open-hearth, and in many cases worthless. The percentage of good castings did well if it reached 40% of the charge. The cost of castings ran about 6 to 7 cts. per lb., and the selling price from 4 to 5 cts. If 10 heats were got one day the vessel had to be relined the next day. In the few cases where the firm succeeded, it was either wise or lucky enough to get good men who understood the steel business and to leave them alone.

The loss, which has been a great drawback to the converter, is not the fault of the process but of the inexperienced or careless operator. You would not put your open-hearth furnace in charge of a green man, but in most cases that has been done with the converter.

With proper blowing, the main loss comes from the silicon in the charge, usually 2%, which is oxidized along with iron and manganese to form the slag. The writer learned to blow with 2% silicon, but for the last three or four years has been blowing iron analyzing from 0.90 to 1.25% silicon from the cupola in 2-ton charges, and very often has been obliged to use scrap while blowing. Another advantage is the increase in the amount of scrap which can be carried, and which helps to cut down the cupola loss by increasing the carbon in the charge. For example: I charge 50% of pig with about 3.75% carbon and 50% scrap with 0.25% carbon. Tests of the cupola iron ran 3.25 to 3.50% carbon, a gain of 1.25 to 1.50% of carbon taken from the coke instead of bought in the form of pig iron. Regardless of what has been written, 50% of scrap can be melted in the cupola with good results and using only 12½% of coke, but your blower must have a complete knowledge of cupola practice.

With ordinary care, the steel produced in a converter is very uniform in carbon and silicon, more so than the open-hearth. The greatest variation seems to be in manganese. The temperature of the metal and the condition of the slag causing more of a variation than in acid open-hearth practice. It is possible to run several weeks without taking an analysis and find at the end of the run very little variation in the elements. This is possible in acid open-hearth, but never practiced, as the risk is great, while I have known of it being done right along in converter practice.

In the making of molds, etc., the practice is identical with open-hearth, except that the castings are for the most part lighter. The ordinary converter shop with one 2-ton converter can produce between 100 and 150 tons of good castings per month, blowing three times a week. It should not be expected to carry the overhead expense of a shop turning out 500 to 600 tons, yet this has often been the case. The management must be good, and the officers' salaries as reasonable as possible; otherwise the shop is doomed to failure, regardless of the quality of its product.

The Small Open-Hearth Furnace for Steel Castings.

By W. M. CARR.†

The open-hearth process for the manufacture of steel is gradually gaining ground, as can be proved by statistics. The reason for its supplanting other methods is mainly one of quality. Further the basic open-hearth process permits a mixture of pig-iron and miscellaneous steel scrap of a lower grade and cheaper price than raw material necessary to other processes. Steel castings may be manufactured in small furnaces having capacities of ½-ton to 2 tons per heat, moderate furnaces of 2 to 5 tons, and large furnaces of 10 to 25 tons capacity per heat. The advantages are as follows:

(1) The small capacity furnaces cost less to install than any other steel-making devices, excepting only crucible melting furnaces.

(2) The economy in operation of open-hearth furnaces in any capacity over that of any other steel making process.

(3) The certainty of results, the greater degree of control in operation and the reduction of the personal equation to the lowest possible expression.

It is generally known to the foundrymen that the largest production of steel castings comes through open-hearth furnaces of capacities of 5 to 25 tons per heat. Such practice is established and requires constant demand to be profitable, and investment of considerable capital varying with the size of the plant.

It has been thought that capacities of less than five tons per heat are not possible by open-hearth methods. The author, however, has had the opportunity to demonstrate the possibilities of the miniature open-hearth and has found from actual practice that they are economical, and comparing operation costs with standard capacity furnaces bear equally well in economy. This fact is somewhat of an innovation, but nevertheless true, and it can be said that the operating cost of the miniature open-hearth is less than that of any type of steel-producing unit or process making steel in equal quantity.

With open-hearth furnaces designed to use producer gas and which rarely go below five tons capacity it is not possible to adapt them to intermittent operation. Even in the smaller producer-gas fired furnaces the roof span is considerable, resulting in heavy stresses on the side walls and binding. These stresses will vary as the furnace may be heated and cooled, and if such alterations are frequent there is danger of collapse of the furnace. It becomes necessary then to maintain them at a steady temperature, and unless there should be demand for regular tonnage the fuel consumption during idle periods would be a constant expense.

In miniature open-hearth furnaces, owing to the comparatively narrow hearth chamber, the roof span is of course lessened and therefore whatever expansion or contraction there may be following heatings and coolings, will result in comparatively slight stresses. The miniature open-hearth is most satisfactory in the rolling type with the body cylindrical, so that the stresses even though slight will be evenly distributed, whereas in a rectangular form the roof will always rest and thrust upon the inside walls. In fact the miniature open-hearth is not recommended to be built in the stationary type.

In conclusion, the miniature open-hearth is not costly to install, is comparatively simple to operate, gives results equal to standard open-hearth practice, makes better steel than the regular open-hearth and can show costs equally as low per pound of molten metal in the ladle.

*Columbus, Ohio.

†New York, N. Y.

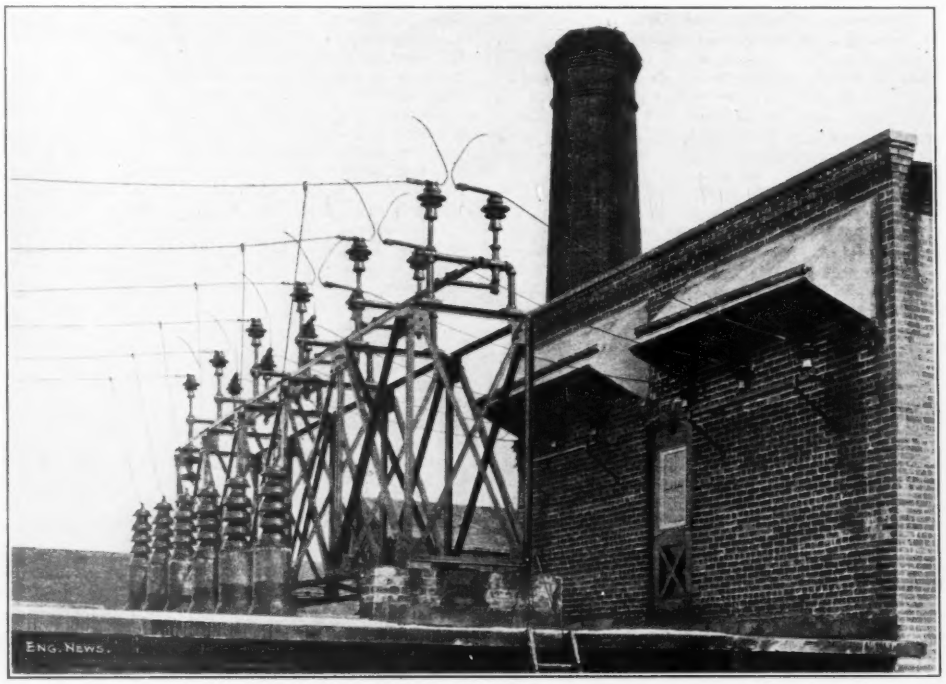

FIG. 1. HORN GAP INSTALLATION FOR 35,000- VOLT ALUMINUM LIGHTNING ARRESTER, SHOWING ROOF AND WALL ENTRANCES AT SCHENECTADY TERMINAL.

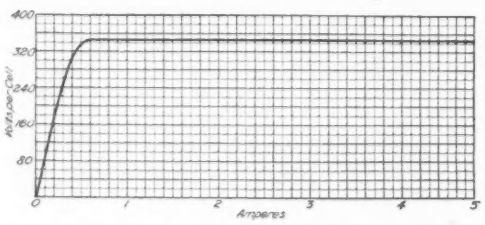

Fig. 2. Characteristic Curve of a Single Cell of Aluminum Lightning Arrester.

An Aluminum Lightning Arrester Installation.*

Modern high tension electrical transmission lines have created a demand for large improvements in the means of protection against damage from accidental grounds and discharges of lightning, and this demand has resulted in the production of the device known as the aluminum lightning arrester.

A thoroughly modern installation of aluminum lightning arresters has been recently put into use to protect the transmission system of the Schenectady Power Co.'s 40 cycle, three-phase generating station on the Hoosic River, near Schaghticoke, N. Y. From this station, 12,000 KW. at 32,000 volts are transmitted to the works of the General Electric Co., at Schenectady, N. Y., a distance of 21 miles. The transmission lines are in duplicate and are supported on specially constructed steel towers fitted with the link type of suspension insulator (described in Engineering News, Aug. 8, 1907). A ⅜-in. stranded steel

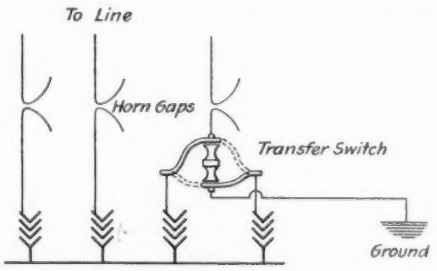

Fig. 3. Wiring Diagram for 35,000-Volt Aluminum Lightning Arrester; Non-Grounded Neutral System.

*From information furnished by the General Electric Co., Schenectady, N. Y.

cable grounded at each tower, is supported above the transmission wires as additional protection against atmospheric discharges.

Although the line crosses both the Hudson and Mohawk valleys at points where electrical storms are notoriously severe, no special protective apparatus was designed. The generating station and likewise the substation at the Schenectady end is equipped with aluminum arresters of the standard pattern and they are reported to have given entire satisfaction ever since the time of their installation.

The arrester equipment at the Schenectady terminal is shown in the accompanying illustrations. The main lines enter the station through six roof-entrance bushings as shown at the left,

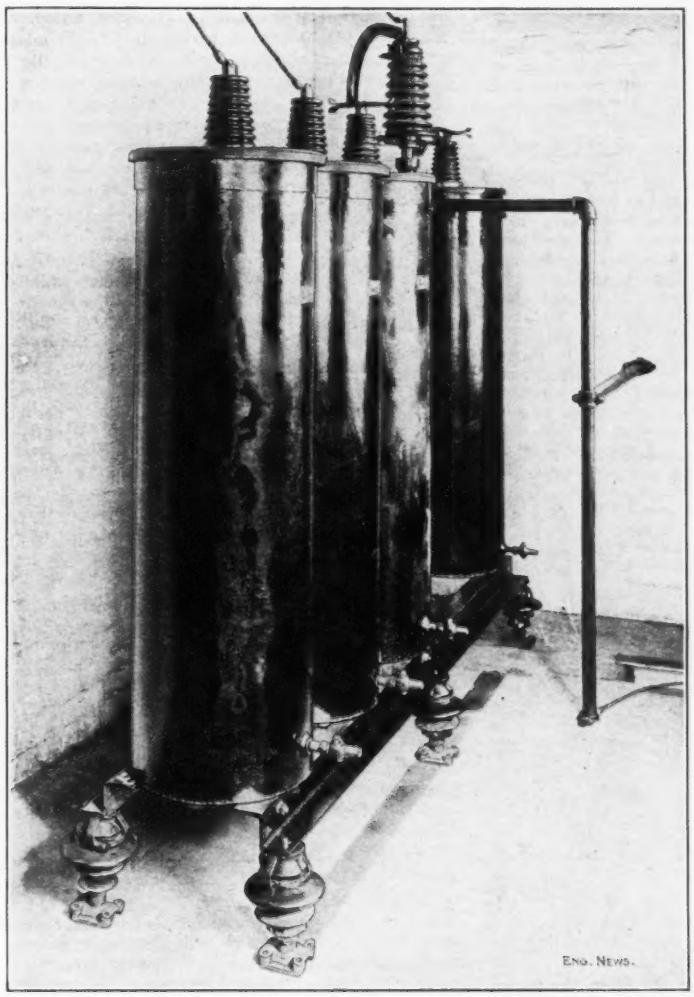

FIG. 4. ALUMINUM LIGHTNING ARRESTER FOR 35,000-VOLT, THREE-PHASE TRANSMISSION LINE; NON-GROUNDED NEUTRAL SYSTEM.

in Fig. 1. The arresters are installed in the raised portion of the station, at the right. At the top of the steel framework on the roof, between the entrance bushings and the raised portion of the station, are shown the adjustable horn gaps placed between the arresters and the lines. Besides serving as spark gaps to prevent full voltage from being continuously impressed on the arresters, they can be used as short-circuiting switches, by virtue of their adjustability, and are used in this way to momentarily connect the arrester with the line for the purpose of renewing electrodes of the aluminum cells, as will presently be explained. The gaps are arranged so that one horn of each pair may be revolved about its support 90°, so that they serve as disconnecting switches to isolate the arrester from the line when desired. In Fig. 1, the three farther gaps are in the disconnected position.

The interior view of the arrester room, Fig. 4, shows only one of the two arrester sets of the duplicate installation. The height of the tanks from the floor to top of insulators is about 85 ins. and the length of the supporting frame is about 93 ins. At the Schaghticoke end of the line the arresters are installed in fireproof compartments in the rear of the switchboard, while the horn gaps are placed on the powerhouse roof.

Each arrester unit consists of a series of aluminum plates dished to a conical shape and placed in a stack, points down, one above another with a vertical spacing of about 0.3-in. between surfaces. This arrangement is clearly shown in the sectional view, Fig. 5. The spaces between cones are partially filled with an electrolyte so that the stack is virtually a system of electrolytic cells connected in series.

The supporting rods are of wood and the cones are separated by washers of non-conducting material so that the only electrical connection between any two cones is through the electrolyte. The stack of cones with the electrolyte in place is immersed in oil in a cylindrical steel tank with welded seams. The electrolyte has a greater specific gravity than the oil and therefore is not displaced by the immersion. The oil not only improves the insulation between the conical plates, but prevents evaporation of the solution, and, due to its heat-absorbing capacity, enables the arrester to discharge continuously for long periods without overheating.

On both surfaces of each conical plate a thin film of aluminum hydroxide is deposited by an electrochemical process. This film has the property of offering a very high resistance to the flow of current up to a definite critical voltage. As long as the impressed voltage does not exceed this critical value, only a small leakage current can pass through the arrester, but above the critical voltage, the current is restricted only by the internal resistance of the electrolyte. The action of the film in this respect is analogous to a counter-electric motive force, as in the case of the storage battery, which, when charged, resists an impressed voltage, up to about two volts per cell, shutting out the flow of current, but which offers only the internal resistance of the cell to higher voltages.

The hydroxide film is formed on the aluminum plates, in the first place, at the factory by a series of chemical and electrochemical treatments. In use, the film is maintained by the action of the small leakage current already referred to on the electrolyte. If the arrester is allowed to stand with no current passing for more than a day or two, there is an appreciable deterioration of the film, due to its dissolving in the electrolyte, but this deterioration does not take place when the cells are empty.

Aluminum is not, of course, the only material upon which a film can be formed which will have a critical voltage, but is the most suitable for arrester plates for the reason that it gives the highest critical voltage of any material practically usable. As shown by the characteristic curve, Fig. 2, the critical voltage for the aluminum arrester is slightly above 340 volts for each separate electrolytic cell, or pair of cones, with alternating current. By combining a number of plates in series in a stack, practically any desired critical voltage is obtained.

The arresters on the Schaghticoke system are designed to discharge continuously for half an hour, although in actual tests arresters of this type have discharged continuously for two hours. Half an hour, however, is considered sufficiently long to remedy whatever trouble may be on the line. When a phase becomes grounded and the arrester begins to discharge, an alarm bell attracts the attention of the operator. This discharge alarm consists of a single aluminum cell placed in the ground connection to the arrester proper and of an ordinary electric bell in shunt

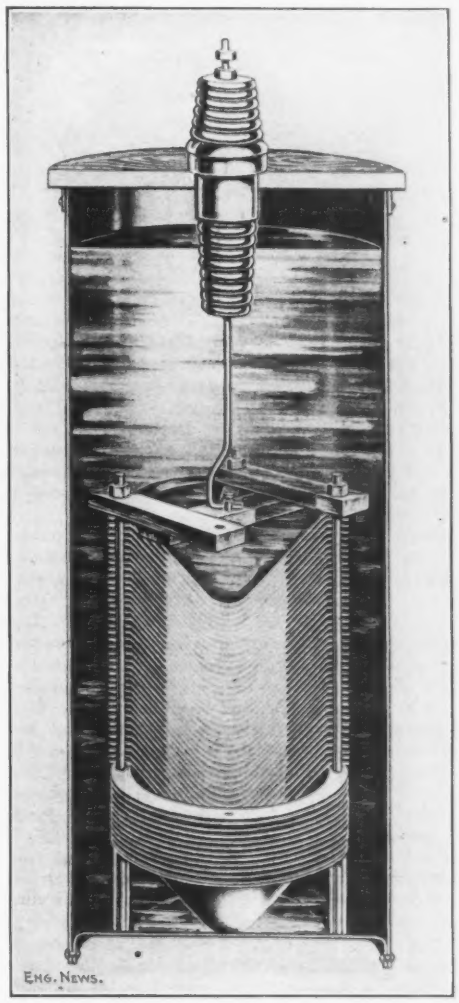

Fig. 5. Aluminum Lightning Arrester; Sectional View Showing Arrangement of Aluminum Cones.

(A few cones at the bottom of the stack are shown complete, while the others are shown in section. The steel tank is filled with oil and the central portion of the spaces between the cones is filled with electrolyte.)

with the cell. The bell rings only when current passes to ground.

Since this is a non-grounded neutral system, four stacks of cones are used. The wiring scheme is shown in Fig. 3. Three of the stacks have each their upper terminal connected through a horn gap to one phase of the line. The three lower terminals have a common connection, which, in turn, is connected to the ground through the fourth stack. This arrangement gives two stacks of cones in series in each case between any two wires of the line and also between each wire and ground.

The renewing of the films on the arrester plates is effected after it has once been put into operation by daily allowing a small current to pass through the stacks for an instant by closing the horn gaps. The presence of the gaps prevents the flow of current through the arrester from the line unless the normal operating voltage is exceeded, hence the necessity of closing the gaps to allow the passage of the small current which is

necessary for the renewal of the films. The transfer switch, shown between the third and fourth tanks in Fig. 4, permits the charging of the fourth, or ground, stack. An inspection of Fig. 3 will show that when the gaps are closed the line voltage is impressed on each of the first three arrester stacks (in pairs), but not on the ground stack. The transfer switch interchanges the connections of the third and fourth stacks so that the third becomes the ground stack, while the fourth is included in the line circuit.

Similar installations of these arresters have been made on other high tension transmission lines in different parts of the country, notably on the system of the Southern Power Co.,* Charlotte, N. C., and the high tension lines of the Animas Power & Water Co. in southern Colorado. The operating record in this last installation is an extremely interesting one, as the number of shutdowns in a single year due to lightning was reduced 88%. In this, as in other installations, the arresters have required no attention whatever except the regular charging required to keep the film in good condition.

Convention of the National Electric Light Association.

The thirty-second convention of the National Electric Light Association was held at Atlantic City, June 1, 2, 3 and 4. On the evening of May 31 the exhibits of manufacturers of electric-lighting apparatus and material were formally opened and this brief ceremony was followed by a reception and dance at the convention headquarters, Young's "Million-Dollar" Pier. The other entertainment features of the convention included a base-ball game between the eastern and western delegates, a vaudeville performance and daily sailing parties.

There were 12 sessions during the convention for the transaction of business and discussion of reports and papers. Four of these sessions were called "general," four were "commercial," two were "technical" and two "accounting." The registration of delegates and guests, on the last day, reached a total of 2,023.

GENERAL SESSIONS.—The sessions opened with the presidential address of Mr. W. C. L. Eglin, of Philadelphia. This address was essentially a review of the year's progress. The growth of the association membership from 2,000 to over 3,000 and the establishment of state and company branches were the prominent features of this growth.

The Committee On a Uniform System of Accounting called attention, in their report, to the points of similarity between the association system and that of the New York State Public Service Commissions, and pointed out how it was acting in an advisory capacity to the Commission.

The following program of papers for the separate accounting meetings was announced by this committee:

(1) "Branch Officers," E. J. Allegaert, Newark.
(2) "Customer's Accounts," L. M. Wallace, Boston.
(3) "Payroll Problems," W. E. Freeman, New York.
(4) "Supplies," J. L. Baily, Baltimore.
(5) "Cost Accounting," H. R. Kern, Philadelphia.
(6) "Depreciation," G. E. Claflin, Boston.

Mr. Alex. J. Campbell, of New London, Conn., Editor of the association's "Question Box," stated in a brief report that a complete revision of all the material that had ever been published was under way, and that the useful material would be compiled, condensed and printed in a loose-leaf handbook. A permanent revision committee was proposed to similarly treat all future material.

The official representative of the association on the National Conservation Commission, Mr. Dudley Farrand, of Newark, N. J., reported briefly the events of the year past arising from the efforts of the past national administration in saving the resources of the country from waste. The manner in which the commission appointed by President Roosevelt had been deprived of authority and power by the action of the legislators was mentioned.

The usual Report of the Committee on Progress was read by Mr. T. C. Martin, of New York City. This was a very voluminous document on progress in the whole field of electric lighting. The 1907 five-year tables of the U. S. Census Bureau were quoted, discussed and compared with a few similar European figures on growth.

The industry has been growing at a rate of 20% a year, but 1908 was marked deeply by the depression that began in the autumn of 1907, which is still felt in many directions. It is to be noted that, according to this table based on the records of the companies themselves, the income and the investment have doubled in the five years; the kilowatt-hour output has increased 133%; the generator capacity has increased 207%; the incandescent service has increased 129%; the arc lamps have increased 44%, and the motor-power service has increased no less than 276%. It is shown that the total receipts of the 4,714 systems in this country were $175,000,000. It is also stated that the output of the stations was 5,858,-121,860 KW.-hrs. This works out at almost exactly 3 cts. per KW.-hr., which seems low.

The recent proposal in Germany to impose a tax upon electricity and gas has had the effect of bringing the statistics for the empire sharply up to date. At a recent meeting of the German Association of Electrical Engineers, the following data were given, as of April, 1909: There were in operation in Germany at that date 1,850 central stations, with a total rating of 1,100,000 KW. These stations sell per year about 900,000,000 KW.-hrs., representing a value of $40,000,000, of which $25,000,000 is for lamps and $15,000,000 for motors. In general terms, the common base-price for lighting in German stations runs somewhere from 10 to 12.5 cts. per KW.-hr. Discounts are, as a rule, less generous than in this country, and returns made a couple of years ago from 139 German stations, big and little, showed receipts from lighting to average just about an even 10 cts. per KW.-hr. The figures for power in the list mentioned average a shade less than 4.5 cts. per KW.-hr., a price considerably above the theoretically equivalent price for gas power, in spite of which the motor load had risen nearly 250,000 KW. in the last two years.

The report also quoted the decisions of the Supreme Court in the cases of the Consolidated Gas Co., of New York City, and the Knoxville water-rates. The increase of public service commissions and the work of the New York and Wisconsin public service commissions were favorably described, particularly in cases where competition had been disapproved, as in the case of the Long Acre Electric Light and Power Co., New York City.

The author of the report cites many instances of unfavorable legislative action to support the statement that agitation for municipal ownership is on the decline. The general increase in the use of tungsten incandescent lamps and in the use of flaming-arc street lamp was commented and unique installations were cited as evidences of the trend of practice.

Mr. Paul Lüpke, of Trenton, N. J., in the paper "Private Policy," made a plea for better generating plants and better men to run them. The first were to be secured, not necessarily by adopting every new development, but by careful study and more reliance on trained engineering judgment. The second were to be secured by a more sympathetic treatment of employees, securing their recognition of their part in giving the public proper service and in advancing the interests of company and employees together. The author recommended that some scheme be devised for training firemen, station attendants, etc., under the auspices of the association and giving them a diploma when their training was completed to a certain extent.

The Committee on State and Company Branches reported that, since the reorganization of the association, to allow state and company associations of members, three geographical and 21 company sections had been formed, having 1,718 members. The control of the local groups is left entirely free in so far as their actions do not conflict with the national association. The report contained forms of constitutions and suggestions for arousing and keeping interest.

Mr. S. E. Doane, of Cleveland, Ohio, Chief Engineer of the National Lamp Association, read a paper, on "The Manufacture of Incandescent Lamps," in which he traced the process of manufacture of carbon-filament incandescent lamps.

The report of the Lamp Committee expressed the great satisfaction that lighting companies were showing in the tungsten filament lamps. Specific data had been sought from the member companies of the association and it was stated that the 200 replies received fairly represented the industry of the country. Fully 75% of the companies used the tungsten lamp and encouraged its general introduction. The opinion was unanimous among them that it was the best available instrument for producing satisfied customers and added revenue.

"The Quality of Light" was an illustrated lecture by Mr. P. F. Bauder, of Cleveland, Ohio. The properties of daylights were discussed under five heads: (1) intensity, (2) color value, (3) direction, (4) ability to reveal detail, (5) adaptability. The several common modern illuminants were compared to daylight by comparing them in these five ways. The color comparisons were made by a long series of colored lantern slides made by the Lumière primary-color process of color photography.

A paper entitled "Latest Developments in Street and Park Lighting," by Mr. J. W. Cowles, of Boston, described the ornamental double and single-arc poles that were being erected in the larger cities to carry light sources of greater power than at present in general use. The progress shown in park and suburban lighting was in adaptations of tungsten incandescent lamps and fixtures.

There were three papers on new arc lamps at the third general section. The first of these, "A Regenerative Flame Lamp," by Mr. A. J. Mitchell, of Cleveland, Ohio, described a regenerative flame arc lamp made by the Adams-Bagnall Co. This is a lamp using one electrode impregnated with fluorine salts and so arranged that the gases from the long luminous flame are carried out of an inner enclosing globe down through condensing tubes, where the heavy dust particles settle, and back up the inner globe. The 5-amp. lamp, using 350 watts gave a maximum of about 1,930 c. p. at 5° below the horizontal. The 7-amp. lamp, without an outer globe, using 490 watts, gave a maximum some 4,100 c. p. at 15° below the horizontal. The great gains made by this lamp are in the long life of electrodes and the efficiency of light production. The author of the paper claimed the predominence of yellow and orange rays in this light shed as an advantage, but some discussions of the paper did not agree with this view.

In "The Present Status of the Arc Lamp for Street and Interior Lighting," Mr. N. R. Birge, of Schenectady, N. Y., described a few types of lamps of very recent development. One of these is a direct-current lamp with a titanium electrode, similar to the now-common 4-amp. "luminous-arc" but designed to be used on 6.6-amp. series circuits with increased power consumption of 510 watts instead of 310. A gain of over 100% in effective illumination is claimed.

An alternating-current luminous-arc lamp was also described. In this lamp two half-round carbon electrodes are held convergent in spring holders below in a titanium carbide electrode placed as in the direct-current luminous-arc lamps. No detailed description of the lamp was given. It was stated, however, that two sizes were to be made; 3-amp., 265-watt and 9.5-amp., 396-watt. The former gave a maximum of 850 c. p. at 10° below the horizontal and the latter of 1,520 c. p. at 15° below.

The older enclosed-arc lamp with carbon electrodes for interior lighting from multiple circuits has developed into the so-called "intensified arc." These are intended to operate with a current of some 5-amps. and have two positive electrodes only ¼-in. in diameter. These replace the single upper electrode of the older lamp, and, as they abut, the arc is always maintained at a definite position and without a feeding mechanism for the upper carbons. The lower negative carbon is 0.375-in. in diameter. These lamps give a maximum of 600 c. p. at 65° below the horizon. This type has also been designed in a still smaller unit for interior work.

*An article on the transmission system of the Southern Power Co. was published in Eng. News, July 7, 1908, p. 45.

These lamp papers aroused but little discussion and were followed by the report of the Committee on Meters. This report is in fact a text-book on watt-hour meters and contains 278 pages on the theories of the several types now in successful use, on proper installation, on testing, etc.

Mr. Philip Torchio, of New York City, in his paper "Future Requirements of Central Station Companies," attempted a general forecast of the trend of progress in the engineering work of lighting companies. Mr. Torchio held that some improvement in the average load factor (ratio of maximum to average load) of the stations of the country was to be expected. It was estimated that the total yearly output of the 3,000,000-KW. dynamo capacity of the country, at the end of 1908, was 6,000,000,000-KW.-hrs. This gives an average load of 700,000 KW. and a load factor of 23%. This low percentage represents the poor utilization of expensive apparatus. Future systems were probable with combinations of all kinds of power generating machinery, such that the most efficient one would operate the longest time and the less efficient (and less expensive) would operate during shorter peak loads.

Mr. Joseph Appleton, of Philadelphia, presented the paper "Advance Information Regarding Developments in Storage Batteries," in which he told of a new lead-battery plate, made by the Electric Storage Battery Co., giving two to four times the capacity of older plates occupying the same space. How this was accomplished was not explained. The author touched briefly on the increased use of storage batteries to wipe out the frequent fluctuations of purchased power, to carry frequent short-time peak loads on generating systems and to help peak-load periods of a few months' duration. All of these uses tend to increase the load factor of the generating apparatus.

The paper "Recent Developments in Electrical Apparatus" was prepared by Mr. E. W. Allen, of Schenectady. Attention was first called, in this, to a new design of alternating-current generator for a vertical Curtis-turbine drive. It was of 14,000 KW. normal capacity at a speed of 720 r. p. m.

The novelty in the electrical design of this machine is due to the high speed of rotation. Broadly speaking, the amount of copper and magnetic material are inverse functions, respectively, of the kilowatt output per pole and the peripheral speed of the revolving field. The machine under discussion has a peripheral speed of 18,300 ft. per min. and an output per pole of 1,400 KW., as contrasted with a peripheral speed of 8,000 ft. per min. and an output of 150 KW. per pole in an engine-driven alternator of the same capacity and frequency operating at 75 r. p. m.

The electrical and magnetic losses in the field and armature of a 14,000-KW. generator amount to approximately 350 KW. This loss for a period of one hour is equal to 1,195,000 B. T. U., and is equivalent to the heat generated in the furnace of a 35-HP. boiler for the same period of time. To conduct this heat away from the generator without permitting local high temperatures requires about 40,000 cu. ft. of air per min. at usual room temperatures.

In order to control the movement of air the generator is totally enclosed, with the exception of the intake and discharge openings at the top and bottom of the armature. When the machine is running the revolving field acts as a powerful fan, receiving air through the opening in the ventilating hood, forcing it through passages provided for this purpose in the field and armature, and discharging it through the opening at the bottom of the generator. This method of ventilation, while well suited to large generators, does not apply to all sizes, and other means will be found desirable in smaller high-speed machines.

Other new ideas were merely mentioned—such as the use of small intermediate poles on direct-current motor and generator fields to help commutation; the combining of belt-driven motors and generators to a single line of general-utility machines that can be easily assembled from interchangeable parts, at the factory, as either generators or motors, open or enclosed, for a wide variety of uses; a rotary-converter for changing alternating current to direct and allowing wide variations in the direct-current terminal voltage without the use of external apparatus. In closing the paper the author called attention to the marked freedom from lightning disturbances on the lines of the Animas Power and Water Co. (Colorado), by the use of aluminum-cell electrolytic arrestors.

	1907.	1908.
Total number of electrical storms.....	34	47
Electrical storms causing complete shutdowns.	8	1
Electrical storms causing partial shutdowns..	17	2
Electrical storms causing no shutdowns.....	9	44

Note.—The only complete shutdown in 1908 occurred at a station unprotected by an arrester.

"Distributing Transformers as of Interest to Central Stations" was the title of a paper by Mr. E. G. Reed, of Pittsburg. The history of the alternating-current "static" transformer, from the Gaulard-Gibbs type of 1882, through the Stanley-Westinghouse designs of 1886 to the modern core and shell types was briefly related. The author included considerable rather elementary matter on the theory of the transformer—such points as operating characteristics, the relation of first cost to allowable internal losses, the saving in losses in very efficient transformers compared with the investment cost of securing the saving.

Mr. Frank A. Vanderlip, President of the National City Bank, New York City, made an address, on "Electrical Securities," in which he explained why so few electric-lighting securities were favorably regarded by investors. Depreciation and antiquation of apparatus were held to be rapid, on account of advances in the art, and so inadequately provided for from the earnings that the profits were insecure. Mr. Vanderlip believed that a period was at hand when investors would look with more favor on electrical securities and capital would be obtained at lower rates. Large combinations of small concerns, both steam and water companies, were to be expected. By these corporations large issues of securities could be put out and the size of the issue would command attention in a way that a multitude of small issues could not. In the extension of the public-service commission control of lighting companies lay greater security to the investor and the acceptance of such control was advised.

In an address entitled "The Electrical Industry," Mr. Geo. S. Graham, of Philadelphia, delivered a "prose poem" tracing the history of electrical discovery from its earliest days of "amber-soul" to the wireless telephone.

The report of the "Committee on Public Policy" was presented in open meeting, although it was intended for executive session. This report took up the same subjects, largely, as the Committee on Progress, paying particular attention to three points. The first point was the decline of municipal ownership agitation. This lack of interest was attributed to (1) the extravagance and inefficiency of municipal operation; (2) reliance of the public on public-service commission regulation; (3) the publication of detailed data on 140 odd municipal plants not considered successful. The second point considered in the report was the attitude of members and companies toward public-service commissions. All legitimate help for them was advised and all legitimate effort toward their establishment, on a conservative basis, where the public was inclined toward such control. The third point raised by the chairman of the committee, Mr. Samuel Insull, of Chicago, was that the securities of the smaller electric-lighting companies were being "raided" by the large manufacturing concern, as they had been several years ago in an attempt to sell their products. No explanation of the "raiding" process was given by the chairman, and this point did not appear in the printed report.

At the executive sessions the report of the Insurance Expert, Mr. W. H. Blood, Jr., of Boston, and the memorials of deceased members were presented. The nominating committee was elected, reported and the officers for the coming year were elected here, as follows:

President, F. W. Frueaff, of Denver.

First Vice-President, W. W. Freeman, of Brooklyn, N. Y.

Second Vice-President, J. F. Gilchrist, of Chicago.

Secretary and Treasurer, F. M. Tait, of Dayton, Ohio.

TECHNICAL SESSIONS.—The first paper presented at these sessions was the report of the Committee on Gas Engines. This was a voluminous document of 114 pages on plants of 150 to 5,000 HP. operating in electric-power stations giving what actual operating data could be obtained. The theory of gas-producers was also outlined and the principal ones on the market were described. There is appended a partial list of the producer-gas installations of the country.

In the paper "Some Features of Condenser and Cooling Tower Design and Operation," Mr. M. R. Bump, of New York City, discussed a few points of greatest importance in securing a maximum transfer of heat from exhaust steam to cooling water at minimum first cost plus operating expense. The cost of pumping the cooling water was stated to depend directly upon the heat imparted to each pound of water and for a minimum the water should leave the condenser as near as possible to temperature of the exhaust steam. This involves large cooling surfaces and the problem of properly balancing first cost against operating charges was held to be a special one for each case. A material saving in the cost and size of condensers, it was stated, had been effected by allowing for a reduced vacuum where the temperature of cooling water was high. The reduction was arrived at by balancing the added cost of fuel, at low vacuum, against the charges on sufficient condenser capacity to secure most efficient thermal operation of the prime mover. The author had found cases where the air and water pumps had been slowed down materially, with the results of reducing the difference in temperature between water discharged and exhaust, reducing the cost of condensing and not appreciably reducing the vacuum.

The portion of this paper devoted to cooling-towers showed computations of the air required for certain cooling effects, etc. A few construction features were described, such as the use of burlap curtain in the towers. The author favored using induced rather than forced draft where natural was not suitable. With natural draft windows in the base of the tower were advised, that the assistance of prevailing winds might be secured. Cooling ponds with spray jets were not favored, as the author claimed that the first cost was high, the capacity limited and the loss of water excessive.

"The Use of Reactance Coil in Generating Stations," by Mr. P. Junkersfeld, of Chicago, was a brief paper opening discussion on the advisability of putting heavy inductance coils into the generator circuits of steam-turbine alternators. Mr. Junkersfeld outlined the benefit that resulted from their use—the limiting of the very heavy short-circuit current of turbine-driven alternators. At the same time it was pointed out that in some ways it was considered a backward step. Mr. A. S. Loizeaux, of Baltimore, in a printed discussion, described in detail the coils that had been installed by the Central Gas, Electric Light and Power Co. There was some discussion as to whether coils should be connected between the generator and switchboard or between the phase windings of the generator and their neutral connection. Dr. C. P. Steinmetz held that this was a matter of station economics, and that in the largest stations it became more essential to connect them outside the generator windings.

Mr. G. L. Knight, in "Some Unique Features of Power-House Design," presented memoranda of some 40 details which were considered departures from standard practice. Among the most important noted were 1,000-HP. water-tube boilers, pneumatic ash conveyor, centrifugal boiler-feed pumps, Venturi meters in water-supply pipes, three condensers for two turbines, a system for indicating in the boiler room the condition of load. There was no discussion, but an invitation was extended to companies to submit memoranda of other new features.

"The Efficiency of Motor-Generators and Synchronous Converters" was the title of a paper, by Mr. F. M. Farmer, of New York City, in which were outlined two series of comparative tests on these apparatuses for converting alternating current to direct. These tests were made

by the Electrical Testing Laboratories of New York City, at stations of the Edison Electric Illuminating Companies, of Boston and of Brooklyn, N. Y. Tests were made of the efficiency of 1,000-KW. units of the following types:

Motor-Generator Equipments.

(1) Generator with induction motor and without step-down transformers.

(2) Generator with synchronous motor and without step-down transformers.

Synchronous-Converter Equipments.

(1) Synchronous converter with induction regulator and step-down transformers.

(2) Synchronous converter with synchronous booster and step-down transformers.

(3) Split-pole synchronous converter with step-down transformers.

The general conclusions from the tests are all that need reprinting here.

In general, the data given in this paper do not justify the use of motor-converters except possibly on 60 cycles or where the alternating supply fluctuates badly. The principal advantage of the motor-generator is its flexibility and the entire independence of the direct-current system from the alternating-current supply is reasonably free from fluctuations, these advantages are of no value and are more than counterbalanced by lower efficiency and increased first cost. Comparisons of the various types of synchronous converters are at the present time in favor of the synchronous booster converter, but the split-pole machine is so recent a development that improvements in design, which will undoubtedly be made, may improve the efficiency curve and the operation of the machine to such an extent that this conclusion may be reversed.

In "The Practical Aspects of Recent Improvements in Transformers," Mr. W. A. Layman, of St. Louis, told of the results of using, in the cores of transformers, a steel containing 3% silicon. The magnetic losses in this steel were so much less than in the older compositions that the sizes and weights of transformers for given capacity had been materially reduced and the efficiency improved. The smaller size allowed less copper to be used and by reducing these simple resistance losses the voltage regulation had been improved. Designers were warned, however, of making the sizes so small that the steel cores would be worked at too high magnetic density, even with small losses, and that proper space would not be left for ample insulation.

The paper "Low-Pressure Steam Turbines," by C. H. Smoot, of New York, was largely a presentation of the claims of superiority, in mechanical features, of the Rateau-Smoot nozzle-expansion turbine over all blade expansion or reaction turbines and over the Curtis nozzle-expansion type.

The report of the Committee on Lightning Protection was brief and contained the results of studies of other reports rather than new investigation. Several recommendations were made as to arrester practices, as follows: (1) Pipe grounds were recommended instead of plate. (2) Arresters should be placed every 2,000 ft. on distributing lines and closer in exposed localities. (3) Various types should be used in mutiple in stations for ample protection against various sorts of disturbances. (4) A steel cable should be strung over the center of transmission lines and grounded at least every 200 ft., as protection against atmospheric discharges.

The Committee on Grounding of Secondary Circuits made a short report in which they stated their failure to have inserted in the Underwriters' National Electrical code, a rule that the grounding of secondary alternating-current circuits up to 150 volts should be mandatory and above 150 volts should be prohibited. The Underwriters' National Electric Association refused to endorse this rule as they could not enforce any rule not based on fire risk. The rule was asked on account of the protection afforded apparatus from high-tension voltages by grounding and the danger to life of grounding circuits with voltages of 200 and over. This report aroused much discussion. Dr. C. P. Steinmetz, of Schenectady, suggested that the association should not take action against the rule of the American Institute of Electrical Engineers (forbidding grounding above 250 volts) and against the English standard of a 220-volt limit. It was voted by the meeting that the report of the committee be received and that its recommendation be approved for lower than 150-volt circuits, but that the recommendation as higher-voltage circuits be referred back to the committee. It was voted also to be the opinion of the section that grounding to water-pipes was the safest method and to be recommended.

The Committee on Overhead Line Construction in its report stated that it had started with the intention of arranging a handbook that would completely cover the design and construction of lines. The work proved to be so great that it was decided to complete the sections on poles and line wires, leaving for the future committees the rest. In the words of the report, it

includes detailed specifications covering construction methods for pole setting, pole guying, attaching of cross-arms and for the running of line wires thereon, together with specifications for material to be used in connection with the work covered.

The construction methods apply to the running of series street lighting circuits and to constant-potential circuits of voltages up to 2,300 volts nominal, including thereunder four-wire, three-phase systems on which 2,300-volt distributing transformers may be used.

Mr. W. K. Vanderpoel, of Newark, N. J., presented the paper "Recent Developments in Secondary Distribution Work," in which he briefly sketched a few methods of running city lines and connections in less unsightly ways, the increasing use of porcelain insulators, the location and support of banks of heavy transformers, ground-connection clamps and back-yard distribution lines in residential districts.

Mr. A. S. Ives, of Poughkeepsie, N. Y., presented "Requirements and Specifications for Extra High-Potential Transmission Lines," in which he related the difficulties encountered in designing a 33,000-volt, 16-mile transmission line. A 13,200-volt line was discarded for the standard voltage (of the American Institute of Electrical Engineers) of 33,000. It was desirable to merely double the old voltage, to 26,400, but as this made an odd pressure the possibility of going above 30,000 for transmission through this part of New York State was studied. Before the advisory committee of the author's company took up the plans, it was generally believed that any voltage over 30,000 would greatly increase the difficulties to be overcome and the disturbances to be cared for, over those incident to transmission lines of 20,000 to 30,000 volts working pressure. The advisory committee after a few months' study and examination found this belief to be erroneous. Even with this point settled they were not able to find existing specifications that could be used for the proposed lines, so few 33,000-volt lines had been built in this country. A complete set of specifications had to be written and the author presented them in this paper.

In the paper entitled "Performance Specifications and Ratings," Mr. W. L. Waters, of Pittsburg, called the attention of buyers of generators to the lack of uniformity in the ratings of generators and motors. It was stated that nearly every maker and purchaser rated their machines and specified their performance in a different way.

The result is that almost every engineer knows examples of units with the same rating, built either by the same or by different manufacturers, some of which under certain operating conditions are capable of carrying 50% more load than others. The remedy for this, of course, is to have some uniform and rational method of rating adopted by all manufacturers, and then to specify and select machines suitable for the work they have to perform.

The two most important points in which specification and performance guarantees are unsatisfactory seem to be: (1) The temperature rise on alternating and direct-current generators and motors; (2) the power factor of the load for which guarantees are made on alternating-current generators.

It was held that the present system of stating temperature rise in any part of a machine for varying periods was unsatisfactory. What was really wanted by the purchaser was, in the author's opinion, the maximum continuous load and the possible overload for two or three hours with a certain room temperature.

The influence of power factors of less than 100% was believed to be too greatly neglected by purchasers, in specifying machinery, and they became suspicious when told that a machine of the desired rating at 100% power factor would not carry over 50% of the desired load under 75% power factor, on account of furnishing full-load currents at half-load power with the current not in phase with the voltage. The author proposed a nominal rating for 100% power factor and in addition the maximum load for lower operating factors.

In "Central Stations in Towns of Less Than 4,000 Population," Mr. J. S. Knowlson, of Schenectady, took up the work of men interested in central stations in small towns, whose problems have not been discussed with the fulness of those in large towns and cities. Such stations rarely had their inception other than as a result to a local demand and were to be regarded much in the same institutional character as fire and police departments. The location, layout, selection of apparatus, distribution of current, operating economics, new business, etc., are very briefly and broadly discussed.

COMMERCIAL SESSIONS.—A long list of papers were presented at the commercial sessions, most of which were of only minor interest to engineers generally. The list is as follows:

(1.) "Methods of Introducing Tungsten Lamps and Their Effect on Central Station Income," Editor, W. H. Atkins, Boston.

(2.) "Practical Illuminating Engineering in Connection with a Commercial Department," G. A. Sawin, Newark, N. J.

(3.) "Intensive Methods of Business Development," John C. Parker, Rochester.

(4.) "Can a Display Room Be Conducted Upon a Profitable Basis?" Frank B. Rae, Jr., New York.

(5.) "Advantages to be Derived from Uniform Commercial Department Forms and Methods," Editor, C. N. Stannard, Denver.

(6.) "Compilation of Load Factors," Editor, E. W. Lloyd, Chicago.

(7.) "Electric Power," Editor, H. J. Gille, Minneapolis.

(8.) "The Advantage of Group or Individual Drive in Certain Installations," C. A. Graves, Brooklyn.

(9.) "New York High Pressure Fire System," Arthur Williams, New York.

(10.) "Relation of the Electric Vehicle to Central Stations," J. T. Hutchings, Rochester.

(11.) "Adoption of Electrical Heat for Industrial Purposes," Editor, Charles J. Russell, Philadelphia.

(12.) "Electricity for National Advertising," George Williams, New York.

(13.) "Isolated Plants," Editor, R. S. Orr, Pittsburg.

(14.) "Central Station Operation of Steam Plants in Connection with Central Station Service," S. M. Bushnell, Chicago.

(15.) "Novel Methods of Advertising in Small Towns," Editor, Alex. J. Campbell, New London.

(16.) "Development of Revenue from Existing Customers," T. I. Jones, New York.

(17.) "Electricity for Domestic Purposes," Editor, M. E. Turner, Cleveland.

(18.) "The Effect of Various Conditions of Maintenance on the Efficiency of Illumination," A. L. Eustice, Pittsburg.

The last paper on this list is noteworthy in bringing out specific data on a need of work that has often been urged in general terms. Mr. Eustice describes a series of tests, made in various cities, on lamps installed in stores, etc., as in daily use and after a thorough cleaning of lamps and reflectors—particularly the latter. The loss of light due to the absorption by the dirt and grime was always a surprise to the owners of the installation. With arc lamps the loss by absorption was shown to be as high as 20%. Common incandescent lamps in prismatic glassware showed as high a figure. Tungsten-filament lamps in prismatic glass shades varied from 8 to 40%. Nernst lamps were uniformly lower running between 1.5 and 10%, with an average of less than 5% loss by the absorption of dust and dirt.

A GREAT PARKWAY FOR PHILADELPHIA, to extend from the City Hall to the Green St. entrance of Fairmount Park, has been authorized by the two branches of the Council of that city. This is the outcome of a number of years of agitation. Estimates of cost of the parkway, including extensive taking of land and demolition of buildings, range from $12,000,000 to $25,000,000.

Future Requirements of Central-Station Electric-Lighting Companies.*

By PHILIP TORCHIO,† M. Am. Inst. E. E.

The important elements affecting a forecast of the future requirements of central station companies are the expectation of growth of the industry and the character of apparatus required. The growth, everybody is agreed, will be very large. The types of apparatus will mainly depend upon the developments of central station practice in generating, distributing and in commercial applications of electricity. Therefore, the main interest of the manufacturer is to have a general forecast of the technical trend of the industry during, say, the next ten years.

CHARACTERISTICS OF CENTRAL-STATION SERVICE.—We have not available a recent census of the central-station electric-light industries in this country, but we may estimate that at the end of 1908 there were in operation 3,000,000 KW. dynamo capacity in generating apparatus and that the total yearly output for 1908 was 6,000,000,000 KW.-hrs. On this basis the average load for the year would be approximately 700,000 KW., and the load factor (the ratio of 700,000 to 3,000,000) approximately 23%. This load factor is an index of the poor utilization of the generating apparatus by the consumers of electricity.

This low load factor is mainly caused by the peak loads of short duration, which make it necessary for the central station to provide a great excess of generating capacity above the capacity required for the average load. As an illustration of the results of these peak loads I would state that 97% of the total output of the New York Edison Company is produced by 50% of the total generating capacity of the system, while the remaining 3% of the total output is generated by the remaining 50% of generating capacity installed. In other words, it may be stated that 50% of the generating apparatus is operated at approximately 46% load factor, while the balance of generating apparatus is operated at only 5 or 6% yearly load factor.

PROGRESS IN 25 YEARS.—In a forecast of the future it is essential to make an estimate of what will be the improvements in the yearly load factor. To this end it is interesting to look back to what has been accomplished in the past, and I herewith give the yearly load factors for the New York Edison Co. from the years 1884 to 1908, inclusive.

Year.	Load Factor, Per cent.	Year.	Load Factor, Per cent.	Year.	Load Factor, Per cent.	Year.	Load Factor, Per cent.
1884	19.3	1891	20.7	1898	23.9	1905	26.1
1885	16.8	1892	20.1	1899	23.0	1906	26.9
1886	19.0	1893	21.5	1900	24.5	1907	30.7
1887	18.6	1894	21.1	1901	25.1	1908	29.4
1888	17.2	1895	20.7	1902	26.0		
1889	15.2	1896	22.0	1903	27.5		
1890	20.7	1897	22.4	1904	26.7		

These results were obtained from a general commercial lighting and power service, excluding current sold for railway service, and they therefore represent the progress obtained by the greater diversification of services and uses of electricity during the last 25 years. It may be said that the improvement in the load factor has been disappointingly small and there is therefore left considerable room for the exploitation of ways and means for utilizing to better advantage the enormous capital outlay of the central station lighting companies.

FUTURE ADDITIONS.—From the central station standpoint, however, future additions should be undertaken with a view to securing the greatest economy under the operating conditions of poor load factors and heavy peak loads of short duration. Looking at the problem from a broad general standpoint it may be stated that a central station company would obtain the greatest economy by having 50% of its generating apparatus of the greatest possible efficiency with less emphasis on the cost of the equipment, and 50% of its generating apparatus of the cheapest kind, practically regardless of its operating efficiency.

Here lies a big field for the cooperation of the manufacturer and central station in arriving at a satisfactory solution of the problem of blending into a well-organized and reliable system the operation of different sources of power generation, comprising steam engines, steam turbines, gas engines, water-power transmission lines, storage batteries, steam accumulators, etc. The guiding rule in the operation of such combined systems should be that the longer one operates the efficient apparatus and the longer he keeps the inefficient shutdown or inoperative, the larger will be the commercial returns.

FUTURE DEVELOPMENTS.—Before coming to a review of the specific apparatus required in the future, it is hardly necessary to state that in pointing out the possible lines of departure from present practice it is not intended that the changes are here recommended for immediate adoption, as the progress will necessarily be gradual.

Frequencies, etc.—The existing standard systems of generation and distribution are so well established that there can be no uncertainty as to their continuation over an extended period in the future. It may, therefore, be forecast that the future growth for many years to come will be along the lines of present frequencies of generating apparatus and voltages of distributing mains. Direct-current systems and alternating-current systems will approximately keep apace in this growth.

Generating Stations.—Means to regulate and rapidly increase the output of steam boilers for peak loads or emergencies will be applied. Gas and oil burners auxiliary to coal firing have been experimentally tried and are very promising.

Large accumulators of superheated water, at 212° and over, in combination with low-pressure turbines may afford means for meeting sudden peaks of load saving the operation of banked boilers, etc.

Smaller companies will benefit by the experience of larger companies in purchasing their new equipments of steam-turbine units, which will in future be the standard steam apparatus. Larger companies will perhaps consider the possibility of obtaining larger units than the present 14,000 and 15,000-KW. units now in use. It is, however, doubtful if either the user or the manufacturer will in the next few years attempt to develop units of 25,000 or 30,000-KW. capacity, on account of the small theoretical increase in efficiency that can be accomplished by further increasing the size of units; also on account of the relatively small saving in cost and space and other attendant limitations of such units to comparatively few customers.

I believe there would be room for a direct-current, turbine-driven generator of 1,000 or 2,000-KW. capacity, provided it can be made reasonably efficient and as reliable as an alternating-current generator. The demand for these units would be distributed throughout the country and would come from a great many other sources independent of the lighting industry.

Desirable improvements on existing turbine generators are—greater mechanical strength and rigidity of winding and supports, and means for promptly extinguishing the fire on a generator becoming short-circuited. Forced ventilation on winding will play a great part in the design of electrical machinery, in this respect reverting to the same expedients adopted in the early Jumbo dynamos.

In connection with existing steam-engine plants, a low-pressure turbine equipment affords the readiest and cheapest means of increasing the capacity of the station and improving its production costs.

Gas engines with producer gas will undoubtedly come into the central station field. They hold out the promise for the greatest economy of operation under the general lines outlined in the preface of this paper. Small companies supplying both gas and electricity would undoubtedly secure better all-around economies by operating gas-engine-driven generators in conjunction with their manufacture of gas than by operating both a gas and a steam plant.

Distribution.—The methods of line construction and installation are now well standardized. One of the important problems yet to solve is the protection of cables against electrolytic action caused by stray railway currents.

Rotary converters of 2,500-KW. rated and 3,750-KW. overload capacity are now being installed. This size will probably mark the limit for the immediate future. Induction regulators of 375-KW. capacity are used. Split field regulation can be used where large range of regulation is required and floor space allows it.

Storage batteries for emergency service, giving from two to three times the output of the usual standard type of central station batteries, can now be installed to take the same floor space as the former batteries and at a cost per KW. at high rate of discharge approximating one-half the cost of the former standard type of batteries.

If the manufacturers of aluminum shall entirely cease to adjust their prices in percentage of the prices of copper, aluminum may become a valuable substitute for copper in the making of wires and underground cables. At present prices, aluminum offers about 10% saving for large sizes of underground cables.

Applications of Electricity.—An electric refrigerator for general household use would replace the ice man and his bills, probably amounting on the whole to more than all the electric lighting bills. Also artificial-ice companies should logically depend for power upon the central station companies.

A differential rate meter for electricity used for heating and cooking would make practical the use of electricity where the lighting rates are now prohibitive. A modern 100-mile electric vehicle would fill the requirements of a large class of pleasure and commercial vehicles. The electrical vehicle has not kept pace with the immense improvements made in gasolene-engine vehicles, and we should expect important improvements in the next few years. The alternating-current central stations also should assist the manufacturer, who is dependent upon this cooperation for his ultimate success.

*From a paper read before the Convention of the National Electric Light Association at Atlantic City, N. J., June 1.

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A Hearing on Electric Headlights Before the Indiana Railroad Commission.

[Contributed.]

The electric locomotive headlights now in use on a number of Western railways were generally condemned by some 60 railway operating officers representing practically every railway in Indiana, who were called into conference by the Indiana Railroad Commission, on May 27.

The recent Indiana legislature attempted to pass a law requiring railways to equip their locomotives with electric headlights of from 1,000 to 2,000 candle power. In its place an act was passed empowering the State Railroad Commission to investigate the efficiency of the headlights now in use, determine the best and enforce an order for its installation. During the conference Commissioner Woods questioned the Superintendents of Motive Power, General Managers, Master Mechanics and locomotive engineers present and in every instance they condemned the electric headlight and declared in preference of the old style oil headlight.

The causes assigned were that the electric light is too intense and an engine runner looking ahead into the strong light for a few hours has his color perception blinded to such an extent that he is unable to distinguish the color of the signal lamps along the road.

In proof of this reports were read by several engineers of practical tests made with engine runners selected for the purpose who had recently been examined for color blindness and had passed successfully. These men were tested by displaying "surprise signals" after they had run an engine with electric headlight for some time. A majority of the enginemen reported a red lamp as light yellow and a yellow as grayish white. Both blue and green lights were reported as gray.

When questioned as to the matter of costs, the railway officers declared that the selection of headlights was not a matter of cost with them but one of safety to the traveling public. The cost of the oil headlight was given at $20 to $50; that of electric headlight at $250 to $300. It was declared by those who wished to emphasize the dangers of the electric light that they would not install them on their engines if it could be done free of cost.

Of the three locomotive engineers present, but one had had experience with electric headlights. He approved all that was said against the electric headlight, and gave it as his experience that the lights frequently went out on the road, and there being no time to find the trouble, it was often necessary to hang out a lantern and drive ahead with the train.

When questioned as to whether or not there was any need for a stronger light than the oil light, the locomotive engineer said there was no such necessity; and that greater safety would result if the electric headlights were done away with altogether. Other engine runners and superintendents stated that many railways had discarded the electric light and that those retained on high class trains were for the novelty or for advertising the train, and not because they were conducive to safety.

The arguments against the electric headlight were a revelation to the Commission. Chairman Woods announced that the Commission would make practical tests of all the different kinds of arc, incandescent, acetylene and oil headlights now in use before ruling on the question. The Big Four and Pennsylvania representatives quickly volunteered to furnish trains and equipment for such tests. Another conference will be held on June 10, at which time the Commission desires to hear from practical electricians who may wish to give an illustrated demonstration of the use of the electric headlight and the means of reducing or softening the intensity of the rays of light.

THE CAMERON SEPTIC TANK PATENTS are to be tested in Canada, it appears. It is reported that the Cameron Septic Tank Co. has claimed royalties from a number of Canadian municipalities, including Berlin, London and Hamilton, Ont. A meeting of the towns involved in these royalty claims has been called for June 15, to be held at Toronto.

A Hearing on Reinforced Concrete in the Revision of the New York Building Code.

The Aldermen of New York City have been engaged for some time in revising the city's building ordinances. The existing code is some seven or eight years old, and it has become out of date in many respects, besides having many features that were severely criticised at the time it was formulated. About three years ago the Board of Aldermen appointed a Commission to draw up a revised ordinance, but when this Commission had just completed and reported its work the Administration changed. The Board of new complexion decided to do the work over again.

Its deliberations, continued over two years, produced two drafts of a Code, reported by the majority and the minority respectively, and made public in the "City Record" of May 20, 1909. Protests were promptly made against these documents, most strongly against the majority code. The chief point of attack was the discrimination against reinforced concrete. This material is virtually restricted to buildings not higher than 75 ft. in the majority code and 85 ft. in the minority code.

Public hearings on the code revision were demanded, although such hearings had been held by the committee of the board before it began its work of revision. The Board therefore ordered such hearings, and the first of these was held on June 2. It dealt with but two subjects: Fire Limits, and Reinforced Concrete. Some extracts from the statements made at this hearing will, we are sure, be of interest to engineers generally.

FIRE LIMITS; ATTITUDE OF THE COMMITTEE.—The hearing on Fire Limits consisted of a number of protests by real-estate men against the extension of fire limits. It is of interest because the remarks of the chairman (Alderman Kenneally) give an explanation of the committee's attitude toward the subject:

I will say, speaking as the Chairman of the Committee and also in behalf of some of the Brooklyn members of the Committee, that the fire limits of the present Building Code will be submitted to the Board of Aldermen; that is, the limits will be left as they are to-day in Brooklyn until the real estate interests in Brooklyn can get together and decide on what they want.

The Building Committee does not feel that it wants to give the real estate owners or the builders in Brooklyn something that they do not want. We want to extend them every courtesy and we want to help them. If they can suggest something which is satisfactory to all concerned in Brooklyn I am positive that the Committee will handle it to their satisfaction.

Reinforced Concrete and Cinder Concrete.

The hearing on concrete was restricted by the chairman to those sections of the proposed code which deal with general building construction of reinforced concrete, i. e., not referring to floor construction, partitions or elevator enclosures, fireproof covering of steel frame, etc. Further, it was restricted to remarks in opposition to the proposed code.

Of the numerous criticisms only a few can be given here. We have selected those which seem to be of more general bearing.

RUDOLPH P. MILLER, M. Am. Soc. C. E. (Consulting Engineer; speaking for Allied Real Estate Associations and Association of Architectural Engineers).—I think both reports, the Majority and the Minority reports, do an injustice to reinforced-concrete construction and do an injustice to the taxpayers who should be entitled to utilize that construction if it is for their interests so to do, and I say that it is for their interests so to do.

Reinforced-concrete construction has been demonstrated to be a thoroughly fireproof construction. We need refer only to the remarkable occurrence in the Dayton Motor Car Works, where a fire which originated in the reinforced-concrete construction was limited to the single floor in which it originated, whereas, passing into an adjoining wing of ordinary construction it destroyed the entire wing.

In the matter of the provision for the strength of reinforced-concrete construction, I have no fault to find particularly with the recommendations of either the Minority or Majority reports. The recommendations, I believe, are more liberal than those at present enforced. The recommendations of the Minority report represent more nearly the present day practice.

However, the injustice done to reinforced concrete lies not in these provisions as to the strength of the construction, but in the restrictions placed upon that type of construction. Why should there be any such restrictions? You have made very good conservative provisions for the strength of the construction. The construction is undoubtedly fireproof. Why limit it in any way? Let it go to any limit. The law must be complied with as to the strength of the construction, so long as it is strong enough, what need have we more for restrictions in this construction?

The restrictions lie in the clause called "Classification of Buildings." Here one report wants to limit it to a construction 75 ft. in height and the other 85 ft. in height, but in the very buildings in which the construction is so provided for, a further restriction is made that it cannot be used unless those buildings are less than 59 ft. high, and referring to business buildings the Minority report states that certain classes of buildings, business buildings, shall be of fireproof construction, but it does not recognize reinforced-concrete construction as fireproof construction.

The Chairman: As a practical engineer, do you believe there should be any restriction on reinforced-concrete construction as to the limitation of height?

Mr. Miller: Not as to height. Your restrictions are sufficient when you fix the stresses, the requirements as to strength which are provided properly in both reports. When you have done that you can go to the height of the Tower of Babel and if those provisions are complied with, you have got a good, safe structure.

R. F. TUCKER, M. Am. Soc. C. E. (of Tucker & Vinton, Inc.; speaking for the Building Trades Employers' Association and the Concrete Association of America).—Speaking for the concrete industry of this city, I will say that the rules laid down for design are not unsatisfactory. The restrictions are unsatisfactory. I agree with Mr. Miller and I think it is the consensus of opinion of all engineers that there is not any reason, having fixed the rules of design, why the building should be stopped at 60 ft., 70 ft. or 80 ft. As a matter of fact, the rules of design are self-restricting. You cannot go to a 20-story building in the rules of design laid down in the Code. When you go up to a 12-story you are pretty near the limit, on account of the limit of stresses of the columns laid down in the Code.

We object to any further restriction being put on the reinforced concrete than those restrictions of design already stated and laid down in the Code. If you keep to that, reinforced concrete will restrict itself so far as height is concerned.

We have in this city a number of 12-story buildings. We have over 65 buildings of all types of reinforced concrete in the five boroughs of New York. They have been doing their duty for years and the owners will tell you that the condition of those buildings is equal to those of any other type of construction known and their economy is greater. I think there are more reinforced-concrete buildings in the city of New York than any other city in the country. There has never been a failure on record. The buildings have been put up properly and they are doing their duty to-day under all kinds of conditions.

Furthermore there have been serious fires, four of which I would like to call your attention to: the Thompson & Norris Bldg. in Brooklyn; the Bowling Green Storage Warehouse in 68th St.; The Cavanaugh Bldg in Brooklyn, and the Stollwerck factory in Stamford. These four fires together are not as great as the fire in the Parker Bldg., and the cost of repairing the Parker Bldg. would cover the repairs in all four of these fires; a thousand dollar bill would make good all of the damage done to all four of those buildings.

The Chairman: Do you recommend the use of cinders in reinforced concrete?

Mr. Tucker: In reinforced concrete or as fireproof material?

The Chairman: In reinforced concrete.

Mr. Tucker: No, sir, you cannot use cinder concrete in reinforced concrete.

Alderman Smith: How about the floor arching?

Mr. Tucker: The floor arching construction is a matter on which we have a lot to say and where cinder concrete should be used; and we have the best experts in this room to tell you that.

R. L. HUMPHREY, M. Am. Soc. C. E. (Engineer of Structural Materials Testing Laboratory, U. S. Geological Survey).—I think one of the chief points in favor of reinforced-concrete construction is its ability to withstand fire. I think in the limitations based on it, an arbitrary restriction has been made, which will handicap the use of a very excellent material. I believe that the restrictions governing the materials that enter into the concrete have not been properly prepared.

In the matter of cement, it specifies particularly that it shall meet the requirements of the American Society of Civil Engineers. These requirements simply stipulate what methods of manipulations shall be used in the making of tests, and contain no requirements as to strength, so that if this provision were adopted there would be no standard requirements for Portland cement to be used in the construction of reinforced-concrete buildings, and I believe that would be a decided calamity. It would enable any kind of cement to go in, because under the discretionary powers which it is proposed to vest in the Superintendent of Buildings, the Superintendent of Buildings could say just what cement should be used.

Again, in the matter of sand, it is proposed, that one of the most vital elements in concrete, the standard is not that it shall be a sand of a certain percentage, but that it shall be no poorer than the standard kept in the office of the Superintendent of Buildings.

Now, all that should be definite and specified; it should be defined just what grade of sand is to be required, and in the same way just what grade of stone goes into the concrete.

Mr. Humphrey next criticized those clauses of the majority report which fix permissible stresses for concrete according to the proportions of the mixture. The heading Reinforced Concrete specifies 1:2:4 mixture must be used, and that direct compression shall be limited to 400 lbs. per sq. in., compression in beams to 550 lbs. per sq. in., and shear to 75 lbs. per sq. in. Under the general head of Strength of Materials the following figures are fixed for concrete:

COMPRESSION.

Portland:	
1:2:4, with steel reinforcement	550
1:2:4	400
1:2:5	300
1:3:5	250
Natural:	
1:2:4	100
1:2:5	80

SHEAR.

Portland	75

SAFE EXTREME FIBER STRESS.

Portland:	
1:2:4	50
1:2:5	40
Natural:	
1:2:4	10
1:2:5	8

These peculiar requirements are further illuminated by other clauses which specify Portland concrete for practically all uses to which concrete might be put.

Mr. Humphrey says, about the stress specifications (he was speaking to a lay committee):

Now, to my mind, those very requirements are wrong, because the relations between sand and stone or the gravel which goes into concrete cannot be arbitrarily fixed. They must be fixed in accordance with the void spaces in the materials. If it had said it should not have more than a certain amount of sand and stone, it would be much better, and I can cite an instance to enforce my point.

I had the proportion of the material 1:2:4, and in order to see whether a better mixture could be obtained, the same grade of material was mixed 1:3:6, and gave 50% more strength than 1:2:4. Why was that? Simply because the void spaces had been properly filled, and you had a concrete which was more dense and therefore stronger than the other one. I think in that respect the Commission has overlooked one of the most important considerations, and that is the question of density of the material.

The Majority report differs from the Minority report in that there is probably 100 lbs. difference between the strength of the 1:2:4 concrete. In other words, the concrete submitted to direct compression is 100 lbs. less than that provided by the Minority Code. The Minority Code fixes the strength of concrete in cross-bending at 640 lbs.; the Majority Code fixes it at 550 lbs. I want to say, in my judgment, both of those values are conservative. I believe those stresses are too low. I believe on the basis of compression stresses fixed by the Majority Code that the cost of concrete building will be increased by a conservative estimate at least 15%, and I do not believe there is any justifiable data for such a position.

IRA H. WOOLSON, M. Am. Soc. M. E. (Adjunct Professor of Civil Engineering, Columbia University).—I desire to protest against the enactment of this Majority Code upon the broad principles that the Code does not properly safeguard the public welfare.

In the first place, there are restrictions in the provisions of the Code limiting the use of reinforced concrete in its various forms, which prevents the use of one of the safest and most economical materials in the protection of life and property in the case of fire.

The proposed Code is so framed as to exclude the use of cinder concrete in building construction, and very largely prohibit the use of stone concrete, due to specifications of weight and height of buildings, etc.

As a result of my years of experience in testing these materials (as well as others), I am positive these restrictions are wrong and unjust. Well proportioned and well placed concrete is a most excellent fire-resisting material, and, in my judgment, a first-class cinder concrete, properly proportioned of cement, sand and good furnace cinders, is the very best fire-resisting material of which I know.

There have been in this city and vicinity in the past ten years 25 fire tests upon full-size floors of reinforced

stone concrete construction. Eighteen of these, or 72%, were successful. There have also been 39 similar tests upon cinder concrete construction, and 33 of them, or 85%, were successful.

I presume that the importance of those tests is not fully appreciated until you take into account the severity of the tests. The tests at the present time in this city require that such materials shall stand a fire test of four hours at an average temperature of 700° F., and water shall be applied for 10 mins. against the red hot structure. Now, that is an awful test. It is a very severe test. I do not think it is too severe, because we get plenty of material that will stand it. Nevertheless, it is a very severe test, and when any kind of construction will pass through that fire and that application of water and then when fully cooled will stand a load of 600 lbs. per sq. ft., instead of the specifications, it is a very excellent material.

The cinder concrete which I spoke of, 85% passed that specification, and they were not all 1:2:4, some of them were 1 cement, 2 sand and 5 cinders, and some were 1 cement, 1 sand and 6 cinders, and even as low as 1 cement and 8 cinders, about as bad a thing as ought to be allowed to go into a building, even if used for filling on floor construction. But, strange to say, I have a record of two tests where a 4 and 5-ft. slab passed that specification of test, so it shows it is a good material.

Where very heavy loads are not required on floors, good cinder concrete makes a light, economical and thoroughly fireproof construction, and it is unjust to the public and to the builders to prohibit its use.

I would like to call attention to another test, and that was a test conducted in 1903 in this city, in the Butterick Building, a 15-story manufacturing building downtown. I had occasion on account of some controversy which arose to go into that building after the roof was practically on, and went up on to the fifth floor and constructed a test house in this building running from the fifth to the sixth floor, knocking holes in the walls and using them to make chimneys to carry the smoke to the outside, and we conducted a fire in that building underneath one of the main girders and the cinder concrete floor for 2¼ hours, the temperature varying from 1,000° to over 2,000°, and there was no injury whatever to the floor or to the beams, and they plastered them and went on with the building, and it is as good to-day as it ever was.

I doubt if such a test was ever made before, and yet that is the cinder concrete which you have condemned as a fire-resisting material.

The Chairman: How about the restriction on reinforced-concrete buildings?

Mr. Woolson: I would not restrict it. I believe the design entirely controls the height of those buildings.

Alderman Doull: Among the many tests that you have made in the Columbia University, what do you consider the best fire-resisting material used in construction to-day?

Mr. Woolson: The best fire-resisting material used in construction to-day is cinder concrete without any qualification.

C. L. NORTON (Associate Professor, in charge of Heat Measurements and Fireproofing Materials, Massachusetts Institute of Technology).—As to the height, first, I believe as most of the speakers who have talked upon this subject do, that this is very largely self-limiting, the cost and size and so on of concrete construction—if you want precisely the details as regards strength provided for by this Code—that will limit practically the size and height to which you may carry these buildings.

The question of fireproofing reinforced concrete to my mind stands just here. It is permanently in a class by itself. With the proper reinforcement, with Portland cement, concrete gives you a thing to build with such as is not known in any other way.

Concrete is the best fireproof material if it is under the structural work, and I will say that of the two I consider cinder concrete to be much the best.

If I desire to use any material of the concrete type, for instance, or of any type, to give me the most excellent fire-resisting structure, I should unquestionably use cinder concrete, not the arbitrary mixture of 1:8, which is undoubtedly bad, but 1:2:5. It may be bad in some instances, but by such a proper proportioning as may be necessary it will give you an absolutely dense sound concrete.

I have tested these beams with a view of seeing whether they are going to be permanent. Your reinforced concrete is of very little value if it is going to fall down or rust or something. I have made innumerable tests, going back about fifteen years, and keeping them going day and night to see what this reinforced concrete was going to do to steel work. It is said that cinder concrete was very bad, but I have not found it was except where the cinder concrete was defective, in that it was porous. If it is sound and strong and dense it makes very little difference whether sand is used or gravel or broken stone or cinders.

Under two sections of this Code, in reference to concrete, it is conspicuous by its omission in connection with elevator wells and partitions, and if the Chairman will let me say two words, since these are reinforced concrete partitions, and column coverings, and so on, it would seem to me a grave omission to allow this Code to go on in its present condition without substituting at least upon an even basis the protection of columns and the construction of partitions and elevator enclosures of the most excellent fireproof material of which we know, that is concrete, preferably, to my mind, cinder concrete.

The reason that the cinder concrete is better for these things is that it does not expand so much and does not fall down. Any of these materials expands with heat, brick, terra cotta, concrete of any kind; they do not go to pieces under the ordinary heat, but they expand, they buckle, and it is there that the reinforced concrete, the steel which goes through the concrete, giving it a tensile strength, with good work behind it, makes expansion a matter of indifference, and if the column expands, it does not fall down. If your elevator well expands or warps a little, it gets out of plumb a little, but it stays there and does not let your fire through from floor to floor, as almost every other kind of construction is liable to do, at least, in comparison with the reinforced concrete.

H. W. HODGE, M. Am. Soc. C. E. (Consulting Engineer of the firm of Boller & Hodge).—I simply want to say that I have been engineer for between three and four hundred structures in this city of New York, during the last nineteen years, and have included in my engineering the two tallest buildings in this city.

I think I was the first civil engineer in the city to recommend my clients to the use of cinder concrete. We put it in the Bowling Green Building in 1895. It was then a great novelty, not having been seen in reinforced-concrete buildings before. That building has been a huge success, and since then the use of cinder concrete has come in very generally.

I have used it in a large proportion of the building of which I have been engineer, I have used all the floor systems, but, in my opinion, based on the experience I have had in the last fourteen years, and in the factory tests I have witnessed, which are a large number, I do not think there is any fire-resisting material in the world which equals cinder concrete in floor construction, and I would further recommend it for partition construction.

The Chairman: Do you think there should be any limit on reinforced-concrete buildings?

Mr. Hodge: I do not think there should be any limit on reinforced-concrete buildings properly designed.

The Chairman: You think cinders could be used?

Mr. Hodge: I think cinders could be used for partition construction and in floor construction, not for bearing walls.

A. S. WRIGHT.—I appear for a company who are the manufacturers of a special sort of fireproof material, the Keystone Fireproofing Co. and the United States Gypsum Co. The particular material that they use in the manufacture of their products is gypsum, and that substance is not included in the list of materials permitted by the proposed Code. Therefore, whether or not they are to be allowed to continue in business and use gypsum lies wholly through another provision of the Code in the discretion of the Superintendent of Buildings.

We agree with our clients that their very existence should not be jeopardized by any such provision as that.

W. P. ANDERSON.—I am connected with a contracting firm who make a specialty of reinforced concrete. We have never done any work in New York, but we have done it pretty well over the country.

We built a reinforced-concrete building in Cincinnati with absolutely no structural steel, that was over 200 ft. above the sidewalk. In Seattle, Washington, we built buildings over 10 stories high. In Dayton, Ohio, we built a building over 10 stories high. At the present time in Montreal a building is being erected which was designed for a 10-story building. They are going to erect five stories at the present time.

I see absolutely no reason why the height of a building should be limited in any way in the Building Code.

A WORK TRAIN COLLIDED WITH A FREIGHT June 2 on the Baltimore & Ohio R. R. at Mars, Pa. Three trainmen were killed and two others injured. The work train was bound from Callery to Bakerstown and was running at a high rate of speed when it crashed into the rear of the freight. The accident is ascribed to a dense fog.

TWO EXPLOSIONS DUE TO LIGHTNING were reported during the past week. Several thousand pounds of powder in an army magazine at Cracow, Austrian Poland, were exploded by lightning June 5. Three soldiers were killed and 500 people at the nearby railway station were wounded by projectiles scattered among them by the exploding powder. Forty houses were wrecked and many others damaged.

A box of dynamite in the railway stores at Kingston, Jamaica, was exploded by lightning June 7. Of the two men in the building at the time of the accident, one was killed and the other seriously injured. Reports state that the explosion involved between 2,000 and 3,000 lbs. of dynamite.

THE COLLAPSE OF A WHARF in Lake Ponchartrain at Mandeville, La., June 6, resulted in the death of 10 of the 70 people who were thrown into the water. The excursion steamer "Margaret," instead of mooring at her regular pier, tied up to a small dock intended for skiffs and other small vessels. The steamer's ropes pulled the dock loose from the main pier and the waiting excursionists were thrown into the lake.

THE ST. LOUIS BRIDGE SITUATION has become complicated by the fact that the estimates of cost from actual designs exceed by a considerable amount the bond issue voted for the purpose last fall in the municipal election. The vote was on $3,500,000, which was authorized, but this will be exceeded by the cost of the structure alone, not including real estate or approaches. The plans, however, are not in a final state, since the municipal authorities have not yet reached definite conclusions on such questions as single deck or double deck, precise location of approaches, etc. There is an overwhelming sentiment in favor of building the bridge, but the matter is again complicated by strong objections against the location chosen, which, being about a mile south of the Eads Bridge, is by no means central to the city.

THE FINAL BERKELEY MUNICIPAL ELECTION held on May 22 resulted in filling the four offices of councilmen and school directors in a way eminently satisfactory to the friends of good government. It is interesting to note that the total registration of voters was 8,496. Compared with this there were 5,035 votes cast at the primary election which resulted in a choice of mayor and auditor, and 4,131 in the second or final election which was made necessary to secure a majority vote for councilmen and school directors. The next to the highest vote for councilman at the final election was cast for Mr. Wilbur F. McClure, who now holds and for several years past has held the office of city engineer. Mr. McClure's vote was 2,372, against 2,408 for Mr. Christian Hoff, a former member of the Board of Trustees of Berkeley and a man who assisted in framing the new charter.

A PETITION FOR AN INJUNCTION against the construction of the Bronx Valley trunk sewer, which is to discharge into the Hudson River below Yonkers and serve a number of communities whose drainage is tributary to the Bronx River, has been filed in the U. S. Supreme Court by U. S. Attorney-General Wickersham, acting through Mr. Hugh Gordon Miller, Special Deputy Attorney-General. The injunction is asked for by the U. S. Department of Justice on the ground that material to be conveyed by the sewer would follow the navigation channels of New York Harbor and vicinity, and would injuriously affect property in and about New York Harbor owned by the general government. The work of constructing the sewer in question has been under way for some time past, and a large sum has already been expended upon it.

WOOD PRESERVATIVES.—More than 56,000,000 gals. of creosote and nearly 19,000,000 lbs. of zinc chloride were used in preserving timber in the United States last year. Small quantities of crude oil, corrosive sublimate and other chemicals were also used. These figures are based upon reports to the U. S. Forest Service of 44 firms which operated 64 timber-treating plants. Assuming that, on an average, 1 gal. of creosote, or ½-lb. of zinc chloride, will protect 1 cu. ft. of timber from decay, more than 100,000,000 cu. ft. of cross-ties, piling, poles, mine, and other timbers were treated. Never since timber treating began, on a commercial scale, in the United States has the domestic supply of creosote been equal to the demand. In 1908, 69% of the creosote used by the treating plants was imported. Nearly three-fourths of the imported creosote comes from England and Germany, but some is obtained in Nova Scotia and some in Scotland and Holland. The domestic creosote used by the treating plants was obtained chiefly in New York, Philadelphia and a few other large cities.

Creosote is a secondary by-product in the manufacture of gas and coke, yet not over 20% of the coke made in this country comes from recovery ovens. Were recovery ovens substituted for all of the bee-hive type, enough tar and creosote could be obtained to supply the present domestic demand. There is not sufficient market here for the other products of coal tar, associated with creosote, and it does not pay operators to distill coal tar for one product alone. The zinc chloride used in wood preservation is all obtained from domestic sources according to the reports. Most of it is produced by a few large chemical companies.

Of the 44 firms operating treating plants 12 are railroad companies. The railroads also use many ties treated by commercial concerns. Statistics upon the number of ties treated in 1908 have not yet been com-

piled. In 1907, however, according to Forest Products Bulletin No. 8, of the Bureau of the Census, the steam railroads of the United States used 19,192,000 treated ties, of which 11,217,000 were treated at their own plants, and 7,975,000 were treated at other plants. The electric roads used 664,000 treated ties in the same year, nearly two-thirds of which were purchased already treated. The majority of the treated ties used by the steam railroads was preserved with zinc chloride, while with the electric roads more ties were treated with creosote than with any other one preservative.

TWO HUNDRED VACANCIES in the U. S. Engineer Corps are to be filled by examinations to be held on June 21, 1909, as noted in full in the "Civil Service Examination" Column of this week's Construction News Supplement of Engineering News. These vacancies to be filled are in the temporary positions of junior engineer, surveyor and transitman in the Engineer Department at Large, War Department, for work on the surveys in connection with the Inter-Coastal Waterways from Boston, Mass., to Key West, Fla. The salaries will range from $100 to $175 per month and the positions are expected to continue from six months to one year.

A MASONRY ARCH CARRYING A CANAL across a river in Belgium collapsed on June 4, according to cabled press dispatches, which read:

> The arched roof of the Villebroeck Canal collapsed June 4 at a point where the canal crosses the river Senne. The water in the canal poured through the rent into the river below and a neighboring valley was flooded. The canal boats all are stranded, and traffic is at a standstill.

This calls to mind the similar accident to the masonry arch carrying the Erie Canal over Onondaga Creek at Syracuse, N. Y., which was described in Engineering News, Aug. 8, 1907, p. 151.

EXTENSION OF THE HUDSON TUNNEL SYSTEM from Sixth Ave. and 33d St. to Lexington Ave. and 42d St., New York City, was authorized last week by the city Board of Estimate and Apportionment, and the Mayor has since signed the franchise. The Public Service Commission having previously approved the application, fixed terms of payment and drafted the franchise, the way is open for immediate construction. The present Hudson Tunnel system of the Hudson & Manhattan R. R. Co. includes two tube tunnels under the Hudson River from Cortlandt and Fulton Sts., New York City, to a point in Jersey City, N. J., under the Pennsylvania R. R. terminal station; two parallel tunnels extending thence northerly through Jersey City and Hoboken to connections with the terminal stations of the Erie Ry. and the Delaware, Lackawanna & Western Ry.; from near the northerly end of this line a pair of tube tunnels run easterly under the Hudson River to New York City, landing at Morton St. and continuing east and north through Christopher St. and Sixth Ave. to Twelfth St.; and a two-track reinforced-concrete subway thence north along Sixth Ave. to 33d St. This system is practically completed; the northerly pair of river tunnels and the Sixth Ave. subway as far as 23d St. has been in operation for over a year. Other lines not yet constructed are a branch of the New York City line running east from Sixth Ave. through Ninth St. to Second Ave., connecting with the Rapid Transit Subway at Fourth Ave.; and an extension of the Jersey City lines westward from the Pennsylvania R. R. station to a surface connection with that railway a mile west, to enable the tunnel trains to run by surface tracks westward as far as Newark, N. J.

The extension now authorized, though less than a mile long, gives an important connection to this system, as it brings the line alongside the Grand Central terminal station of the New York Central and the New York, New Haven & Hartford railways. The extension is northerly along Sixth Ave., from 33d St. to 40th St., thence northeasterly under Bryant Park to 42d St., thence easterly under 42d St. (under the present Rapid Transit subway) to a terminal station near Lexington Ave., adjoining the Grand Central Station.

The annual rental which the company must pay for this franchise comprises essentially a payment of $0.50 per lineal foot of single track or of station platform and a payment of $9,000, figured as 3% of gross receipts assumed to be $300,000. These annual payments are to be doubled after ten years, and later are to be readjusted simultaneous with the payments on the franchise for the original part of the line. A single payment of $500 per station entrance is to be made. Sidewalk vault space is to be valued at half the cost per square foot of adjoining property, and four per cent. of this valution is to be paid to the city annually for all vault space used. The city has an option on the line after a certain number of years. Construction must be completed in three years. In accordance with statutes, the franchise is made contingent on the company's obtaining the consent of half the owners of abutting property or else on the favorable finding of court commissioners. The company must hold the city harmless against all charges or damages, and must install the best track construction to avoid vibration or tremor.

Personals.

Mr. Ralph Vandercook has been appointed Assistant State Engineer of South Dakota.

Mr. Frank B. Gilbreth, M. Am. Soc. M. E., has removed his office in New York City to 60 Broadway.

Mr. C. V. Christie, Stud. Can. Soc. C. E., has been appointed Assistant Professor of Electrical Engineering at McGill University, Montreal, Can.

Mr. A. H. Powell has been appointed Master Mechanic of the Salt Lake and Humboldt division of the Western Pacific Ry., with headquarters at Salt Lake City.

Mr. Benjamin Herman, formerly Engineer of Bridges of the Southern Ry., has been appointed Engineer of Bridges of the Queen & Crescent Route, with headquarters at Cincinnati, Ohio.

Mr. J. W. Cowper, Assoc. M. Am. Soc. C. E., has relinquished his position as Manager of James Stewart & Co., contractors, to become Vice-President of the Warden-Allen Co., with offices at 115 Adams St., Chicago, Ill.

Mr. St. George H. Cooke, Assoc. M. Am. Soc. C. E., has changed the location of his office from the Cambridge Bldg., Chester, Pa., to the Real Estate Trust Bldg., Philadelphia, where he will continue to conduct a general civil engineering practice.

Mr. J. S. Calhoun, Jr., formerly Superintendent of Construction with the Simons-Mayrant Co., Engineers and Contractors, Charleston, S. C., is now Superintendent of Construction for the firm of James Devault & Son, in charge of the erection of the U. S. Post Office at Moline, Ill.

Mr. John F. Stevens, M. Am. Soc. C. E., whose resignation as Vice-President of the New York, New Haven & Hartford R. R. was noted in this column June 3, has been engaged by the Great Northern Ry. to inspect and report on water power facilities for that company in Montana and Washington.

Mr. Karl M. Way, formerly Assistant Engineer, Fuel Testing Branch, U. S. Geological Survey, has become Assistant Mining Engineer in the fuel department of the Arthur D. Little laboratory of engineering chemistry in Boston, Mass. Mr. Way is a graduate of the course in mining engineering at the Ohio State University.

Mr. J. E. Hutchinson, General Superintendent of the first district of the St. Louis & San Francisco R. R., has become General Manager to succeed Mr. W. C. Nixon, resigned. Mr. H. F. Clark, Division Superintendent at Sapulpa, Okla., will succeed Mr. Hutchison as General Superintendent.

Mr. J. R. Bibbins, Jun. Am. Soc. M. E., who has been associated since 1902 with the Westinghouse interests at Pittsburg, Pa., recently serving the Westinghouse Machine Co. as Commercial Engineer, will become associated, after June 18, in the work of the Public Service Commission of New York City as assistant to Mr. B. J. Arnold, Consulting Engineer and Director of Appraisals. Mr. Bibbins is a graduate of the University of Michigan, and has served in various technical capacities with the Detroit Public Lighting Commission, the Detroit Edison Co. and the Detroit United Railways Co. in operating and construction work. His new offices will be in the Tribune Bldg., New York City.

A number of changes have been announced in the officers of the Queen & Crescent Route:

Mr. H. E. Warrington, M. Am. Soc. C. E., Chief Engineer of the Queen & Crescent Route, has resigned that position to engage in other business. Mr. Curtis Dougherty has been appointed to succeed Mr. Warrington, but with the title of Engineer of Maintenance of Way, the title of chief engineer having been abolished.

Mr. C. E. Rickey, Division Superintendent of the Queen & Crescent Route at Lexington, Ky., has been appointed Superintendent of Terminals, with offices in Cincinnati, and Mr. W. T. Caldwell, Division Superintendent at Danville, Ky., has been given jurisdiction over the entire line, the division superintendency at Lexington having been abolished.

Obituary.

Orry M. Shepard, formerly General Superintendent of the New York, New Haven & Hartford R. R., died June 1 at his home in New Haven, Conn. Mr. Shepard was born in 1842 at Cleveland, Ohio, and had been in the service of the N. Y., N. H. & H. R. R. since 1882.

Charles L. Buckingham, Assoc. Am. Inst. E. E., died May 31 at his home in New York City. Mr. Buckingham was born at Berlin Heights, Ohio, in 1852 and was a graduate of the course in civil engineering at the University of Michigan in the class of 1875. He afterward studied at the Columbian Law School in Washington, D. C., while employed as an examiner in the U. S. Patent Office. After graducting at the law school, he came to New York City as Counsel for the Western Union Telegraph Co., and has since been continuously engaged in the practice of patent law, giving particular attention to cases involving electrical patents. He was counsel for the General Electric Co., Westinghouse Electric & Manufacturing Co., Edison companies, and other large corporations.

Engineering Societies.

COMING MEETINGS.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-26. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 24-26. Annual convention in New York and Brooklyn. Secy., Arthur L. Williston, Pratt Institute, Brooklyn, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
June 24-26. Summer convention at Detroit, Mich. Secy., Wm. J. Baxter, 29 W. 39th St., New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
July 5-9. Annual meeting at Seattle, Wash. Secy., A. H. Dimock, City Hall, Seattle, Wash.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
July 6-9. Annual convention at Bretton Woods, N. H. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 13-15. Annual convention at Toledo, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 15-16. Summer meeting at Indianapolis, Ind. Secy., W. M. Mackay, P. O. Box 1818, New York City.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—The fourth annual convention will be held in Syracuse, N. Y., June 23-25, at which the following papers will be presented: June 23, "Smoke Abatement in Chicago," Paul P. Bird, M. Am. Soc. M. E.; "The Relation of the Character of Coals to the Prevention of Smoke," D. T. Randall, M. Am. Soc. M. E. June 24, "The Influence of Draft on Economy and Smoke Prevention," L. M. Beers, of Rochester. June 25, "The Elimination of Industrial Smoke," O. U. Bean, of New York City; "Fuel Economy and Smoke Prevention," H. M. Wilson, Chief Engineer, Technologic Branch, U. S. Geological Survey; "The Smokeless Furnace," S. B. Flagg, Jun. Am. Soc. M. E.; "The Legal Aspect of Smoke Prevention," D. Raymond Cobb, of Syracuse, N. Y.

NATIONAL IRRIGATION CONGRESS.—The 17th congress will meet in Spokane, Wash., Aug. 9-14. The secretary is Mr. B. A. Fowler, Phoenix, Ariz.

OHIO ELECTRIC LIGHT ASSOCIATION.—At the 15th annual convention, to be held in Toledo, Ohio, July 13-15, papers will be presented on the following subjects: "Residential Lighting," "The Supplying of Electric Current to Other Towns from a Centrally Located Station," "Engine Room Management," "The Commercial Organization of Electric Lighting Companies and Their Relation to the Public," "Boiler Room Economy," "Factors to Be Considered in Making Street Lighting Contracts," "Plans to Be Followed in Supplying Lamps to Consumers," "The Titanium Arc Lamp," "Tungsten Lamp Experience."

AMERICAN SOCIETY FOR TESTING MATERIALS.—The program for the twelfth annual meeting, to be held at Atlantic City, N. J., June 29, comprises about 60 papers, including a number of committee reports. The papers to be presented at the first session, June 29, treat of a variety of subjects, including insulating materials, fireproofing materials, fuels and steel rails. Those for June 30 and in the forenoon of July 1 are mainly devoted to steel and iron, and include committee reports on specifications for iron and steel, heat treatment and on corrosion. On the afternoon of July 1 and the morning of July 2, papers on cement and concrete will be presented, and those for the session in the afternoon of July 2 will deal with bitumen and oils. The papers for the last session, at 10 a. m., July 3, treat of various structural materials and of clay and cement sewer pipes. Copies of the program may be obtained from the secretary, Mr. Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.